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The Institute of Vitreous Enamellers

The Welsh Engineers' and Founders' Association

and

The Foundry Trades' Equipment and Supplies Association

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The Steel Castings Report

The Third Report of the Steel Castings Research Committee, presented to the London Meeting of the Iron and Steel Institute, is one of the most important documents ever placed in the hands of the foundry industry. Its lessons, whilst far-reaching, are restricted, clear and well defined. First of all came the disturbing thought that sand testing, in many of its aspects, cannot be considered as yielding results which are strictly comparable as from one foundry to another. There is a good deal of "tidying up" before this desirable aim can be reached. The sieve test, for instance, gives different results when mechanically carried out as against when manually effected. The life tests for steel have tended to prove the obvious, such as improved running power being associated with increased superheat and other well-established metallurgical generalities. What was interesting and conclusive was that the experienced foundry staff could prognosticate with remarkable accuracy the running properties of the steels they had prepared. No longer can the cognoscenti sneer when the practical man uses a simple adjective to express temperature or life of a heat of steel. So thoroughly has his opinion been substantiated that doubt is evidenced as to the wisdom of continuing the running power test as a means of control for steel. We wish it to be clearly understood that this remark applies neither to cast iron nor to non-ferrous alloys. For steel it still has its use in the research laboratory, which department can now very usefully turn its attention to the cure of those casts which the practical man will tell them are liable to run sluggishly. Professor Portevin, in his address to the Polish Foundry Congress, a translation of which is appearing in these columns, indicates the nature of the potential causes of sluggish metal, and by their study remedies of a simple character should be forthcoming. Herty's work in this direction is, to our mind, outstanding.

Mr. Hall's work on the strength of steel as it sets in a sand mould should prove most helpful to both designers and makers of steel castings, and the hint that high manganese is useful will no doubt be tried out extensively in practice. Unfortunately, its beneficial effect seems limited to low-carbon steels. It may be that improved strength conditions at very high temperatures will be found as a result of alloying. Finally, we are, in common with the whole of the foundry industry, deeply appreciative of the bibliography which forms Section VI of the Report, which has been compiled by the library staff of the Iron and Steel Institute.

Standardising Standards

Our Dublin correspondent has sent us the following paragraph: "New lamp standards being erected in Dublin were purchased from a French firm because no Irish firm submitted a tender. The Lighting Committee of Dublin Corporation has reported to the City Council that everything possible was done to secure tenders from Irish firms, without result." This paragraph is especially interesting because only recently an English foundry supplied a number of standards no less than 30 ft. high. If this be the type demanded, one can understand the hesitancy displayed by an Irish or indeed any other foundry.

There are still in existence lamp posts dating from before the town's gas era, and correlating this fact with the ability to meet such modern demands as 30 ft. high standards, it might be assumed that cast iron could be regarded as a material worthy of being standardised. Such is not the case, however, but steel and concrete have stolen a march on the foundry industry, and specifications for these are either issued or in process of preparation. At any rate, they are so far advanced that foundries are now receiving inquiries for non-cast-iron standards to comply with British Standards Institution specifications!

It cannot be too strongly impressed upon foundries making cast-iron standards that many buyers imagine, because a material or structure is covered by a B.S.I. specification, that it is thereby the best available. Concrete is not so clean as cast iron, and usually bears permanent and slightly disgusting evidence of canine attention, whilst steel suffers badly from corrosion at the joints and at the base. At the latter position one sometimes sees protection being afforded by concrete. The life of a steel pole is so limited that the incidence of the breakage of cast iron ones is more than counterbalanced when a long view is taken. Because of the mental make-up of the buyer, it is essential that those foundries laid out for the manufacture of lighting standards get together, and with the co-operation of the officers of the British Standards Institution and the technical and buying interests create a standard specification for cast-iron lighting standards—not so much the actual design, but generally in the direction of acceptance conditions for straightness, initial painting, relative section below ground, and so forth. The aspects covered by the specification are not, at the moment, half so important as the physical existence of an actual specification.

Road-Haulage Wages

BY F. J. TEBBUTT.

Road transport is now such an important branch of a business that readers, it is thought, would appreciate a short explanation of the new Road Haulage Wages Act, 1938, which lays down rules for the regulation of road-haulage (goods-vehicle) workers' remuneration. The Act concerns "A," "B" and "C" licence holders, but this explanation will be confined to the provisions particular to "C" licence holders (being those who use vehicles for collection and delivery and so forth in their own business), matters concerning "A" and "B" operators (persons who trade or partly trade in road haulage) having little interest to members of the foundry industry.

Any road-haulage worker (or his trade union) who considers that his remuneration is unfair can apply to the Ministry of Labour for consideration of his case; incidentally, any trade union can apply if the Ministry considers that it represents a substantial number of road-haulage workers. If the Ministry considers that the application is not a frivolous or vexatious one, representations are made to the employer, and if the question is not resolved it must in ordinary cases be referred to the Industrial Court for settlement. If, however, any arrangements have been made for settling disputes in that trade (between an employers' association, the employer being a member, and a trade union), those arrangements must be used; failing a settlement, and at the request of both sides, the matter can then be referred to the Industrial Court.

Fair Wages

The Act lays down that an employer is not to be considered as paying unfair wages (1) if he is paying wages prescribed in an Order under this Act for "A" and "B" licence holders; (2) paying in accordance with an agreement—to which he is a party—made between an employers' association and a trade union; (3) paying in accordance with an industrial agreement operative for the same trade in the same district, although not a member of that particular employers' organisation; (4) paying wages equivalent to those paid by other employers in the same trade and the same district for similar work and workers in pursuance of a decision of a joint industrial council, conciliation board or other body, and (5) paying wages equal to and in accordance with an Industrial Court decision relating to corresponding work in the same district and arising out of a complaint made by a worker employed by some other employer in the district of the same trade.

Duties of Industrial Court

If a case is referred to the Industrial Court (this Court is a permanent body constituted under the Ministry of Labour) and the Court agrees with the applicant that the wages are unfair, it must fix the rate to be paid, called the "statutory remuneration," and it has power to include holiday pay in any determination made.

In any Order made, the daily or weekly hours required to earn the daily or weekly rate, and the nature of the work, must be specified. Furthermore, where an overtime rate is fixed, the normal hours to be worked before the overtime rate is payable must be included in the Order, and also any further provisions as may be necessary to define the employment and for enabling the remuneration payable to be ascertained.

The Court before fixing the remuneration must have regard to the rules (1) to (5) given above, laying down what is fair or unfair, and moreover must take into consideration any agreement there may be (between an employers' organisation and a trade union) concerning workers on similar work in comparable trades and to the general level of wages paid to other workers in the industry concerned and to such other circumstances as the Court may consider relevant.

An Order will ordinarily run for three years from the beginning of the week after the date of the decision (subject to quarterly reviews on an application being made), and will apply not only to the worker making the complaint but to other workers performing similar work for the same employer. As regards the worker concerned in the application, however, the statutory remuneration can be made retrospective for that worker, but not for a period of more than six months before the date of the order. Any employers' organisation the Court considers as having interest in the question under review can appear before the Court and be heard, as can any trade union.

Sundry Matters

This Act will not apply if a minimum rate has been fixed by some other enactment. As an example, if a Trade Board Order includes the power of fixing rates for transport workers of the particular trade, this Act will not apply; it might be of interest, however, to mention that only three Trade Board trades have this power, none having any connection with the foundry trade. Where a worker is employed partly on road-haulage work and partly on other work, the statutory remuneration need only apply in respect of the time spent on road-haulage work. The Act as regards "C" licence holders will be brought in by an Order of the Ministry of Labour, the date being that on which the first road-haulage wages order ("A" and "B" operators) comes into force.

Correspondence

[*We accept no responsibility for the statements made or the opinions expressed by our correspondents.*]

Desulphurising Pig-Iron

To the Editor of THE FOUNDRY TRADE JOURNAL.

SIR,—We have read with very great interest the Paper on "Desulphurising Pig-iron by Ladle Treatment with Soda Ash," by Mr. George S. Evans, published in your issue of October 13. It is evident from this article that the desulphurisation of blast-furnace iron has not reached such an advanced stage in America as in this country and on the Continent of Europe. It is stated that, so far as is known, no one in the American steel industry has ever adequately equipped a plant for desulphurising blast-furnace metal in an efficient manner as regular operating practice, and it is suggested later on in the article that it is impracticable to carry out this process efficiently in the ordinary blast-furnace ladle.

It will no doubt be of interest to the author to know that in England, France, Luxemburg and Germany this process is being carried out as a routine treatment of blast-furnace iron without the necessity for any modifications in the design of the ladles which had previously been used. In addition to the use of sodium carbonate alone, mixtures of which this chemical is the active desulphurising constituent are also used, and between 50 and 70 per cent. of the sulphur present is removed without difficulty.

It has been our experience in this country that there is certain reluctance to adopt a specially designed plant such as is described by the author of the article. Maintenance costs must inevitably be increased by the incorporation of slag trap spouts. It is obvious, therefore, that the proven ability to carry out the desulphurising process with the standard design of ladle offers considerable advantages and economies.—Yours, etc.,

For Imperial Chemical Industries, Limited,
N. L. EVANS.

Northwich, Cheshire.
October 24, 1938.

Random Shots

The annual banquet and dance of the Institute of Vitreous Enamellers in London last Friday proved to be as gay an affair as it hinted to be at the beginning. Its promise of gaiety manifested itself firstly in an excellent dinner, with a succession of dishes which quite definitely bore very close resemblance to the description on the menu. For the first time possibly, in the history of public dinners, the "Salade Japonaise," so often promised with the pheasant, was really Oriental and not just a piece of lettuce still wet from the occidental colander.

* * *

This *repas bien choisi* was rounded off with speeches which sparkled with wit and humour; good stories were plentiful and *bons mots* were peppered about like paprika on a dish of oysters.

* * *

Sir David Milne-Watson spoke of the vitreous enamellers as the Elizabeth Ardens of industry, and recalled the story of Lord Queensbury who, passing a pretty young lady in the street, murmured, half-aloud, "Painted!" The young lady in question was as quick in her reply as she was pretty, "Painted! By God!"

* * *

Sir Harold Hartley, referring to the good relationship which exists between the vitreous enamellers and the producers of the goods upon which they work their wonders, quoted an old but very apt saying:—

"Better a dinner with herbs where love is than a stalled ox where hatred is."

* * *

Mr. John Gardom amused everybody with what he swore was his maiden speech (definitely). He foresaw Sir William Larke going to heaven with a guard of honour composed entirely of secretaries of societies. And he put in a plea for the more rapid development of the canning industry in Burton, a plea greeted by loud cheers from more than one member of the company. If that really was Mr. Gardom's maiden speech, he (quite definitely) should be worth listening to when he has acquired a little experience!

* * *

Sir William Larke's speech—by its very nature light of character (he was replying for the guests)—was full of stories. He told of a lady, arriving at the hotel for the dinner, who was accosted by a good-looking young man with "Good evening, Miss!"

"Sir," replied the astonished lady, "I don't know you from Adam."

"Come, come!" answered the persistent young man, "Surely I'm better dressed!"

* * *

He also told the story of a young lady who stopped rather too long at the traffic lights. Up came a young policeman, fresh from Hendon, who asked very politely "What's the matter, Miss? Haven't we got the colour you like?"

* * *

A third one was about an American who had been expounding on the New Deal for nearly an hour.

"What was he talking about?" asked a member of the audience whose attention was beginning to wander.

"Well, he didn't say," replied his neighbour.

* * *

The final *bon mot* from Sir William was that everyone that evening was enjoying the supreme gift of hospitality, that of good company—a happy phrase which was amply proved throughout the evening's entertainment.

"MARKSMAN."

A General Engineering Foundry*

By F. WHITEHOUSE

The purpose of this Paper is to do no more than discuss certain moulding practices as carried out by the firm with which the author is or has been associated. It is generally accepted that the merits or demerits of a particular practice are not always capable of being immediately decided by reference to moulding principle. There are many other factors to be taken into account, and as far as possible an effort will be made to indicate those governing the final choice of method.

The ideal shop practice, from a personal viewpoint, is that which produces the necessary quality of castings at the least expense, and the whole aim of foundry science and management is to bring that ideal nearer. Everyone should, of course, remember to underline *necessary qualities*, because although a floor-plate with a plate-glass finish may be an artistic delight, it has no commercial significance unless its production is economically sound.

Green-Sand Practice

That the industry as a whole is losing ground in the production of the larger castings in green sand is now generally recognised. There are arguments about the reasons, but it seems obvious that initially the decline in moulding skill is the biggest factor. Possibly the scientific production of a " fool-proof " sand will lead to a revival of an old practice, but at the moment success depends upon good moulders, and they are not as plentiful as one would like to see.

The economic *pros* and *cons* of dry sand *versus* green sand are too well known to bear further reiteration, but for those wanting further details, reference should be made to " The Manufacture of Iron and Steel Castings in Green Sand " which was delivered to the Sheffield Branch as a joint effort by C. J. Dadswell, T. R. Walker, and the author of the present Paper.

The illustrations, Figs. 1 to 4, are not put forward as examples of the largest castings made in green sand. The author is perfectly aware that castings up to 30 tons are regularly produced by this method. These illustrations are merely from personal and fairly recent experience. The only significance they have is in illustrating that, with good moulders to do the job, such castings as these can be produced of satisfactory quality without " scientific " control of the sand and at less expense than by other methods, and that those who make such castings in dry sand on the principle of " safety first " do so from fear rather than fundamental necessity.

An analysis of the precise production methods in the manufacture of these castings would be too commonplace to be permissible, and the author would prefer to lay greater stress on the details of tackle and methods.

The point of this Paper, then is not the best way but certain ways of producing certain castings, the aim being to create interest in various methods. It is proposed to divide the Paper into green-sand practice, dry-sand practice, and loam practice, and submit illustrations of each with the intention of provoking discussion.

The calendar cheek shown in Fig. 1 is only of $\frac{5}{8}$-in. section in the body, and all the air must be brought off at the foot end. A hundred and twenty chaplets are used to hold the cores in position, and in the bottom part, instead of using wooden blocks into which a pointed chaplet is driven, studs are used, and a thin plate 2 in. by 2 in. by $\frac{1}{16}$ in.; the stud is supported by a tapered cast-iron peg about 6 in. long, which is driven about $\frac{1}{8}$ in. below the face of the mould. The stud rests on this, and, after casting, protrudes from the casting about $\frac{1}{8}$ in. When this is chipped off, the plate of the stud no longer shows, and a good surface can be obtained. In the author's experience this method is both quicker and cheaper than the older method.

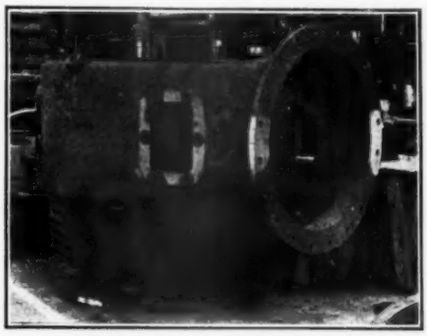

FIG. 4.—BURNER-BODY CASTING.

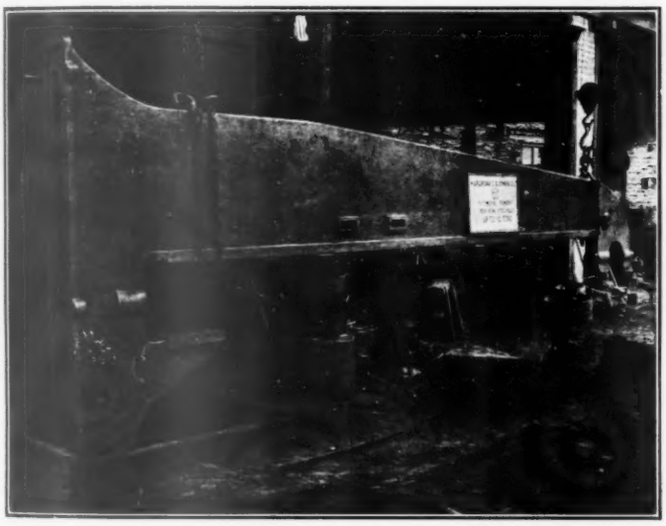

FIG. 1.—CALENDAR CHEEK FOR A BLEACHING MACHINE.

FIG. 2.—A 3-TON BEATER CASTING FOR PAPER-MAKING PLANT.

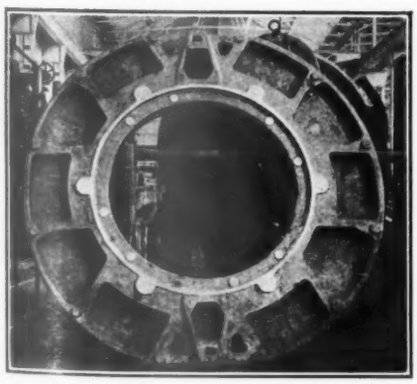

FIG. 3.—RUNNER-BACK CASTING, 8 FT. 6 IN. DIA.

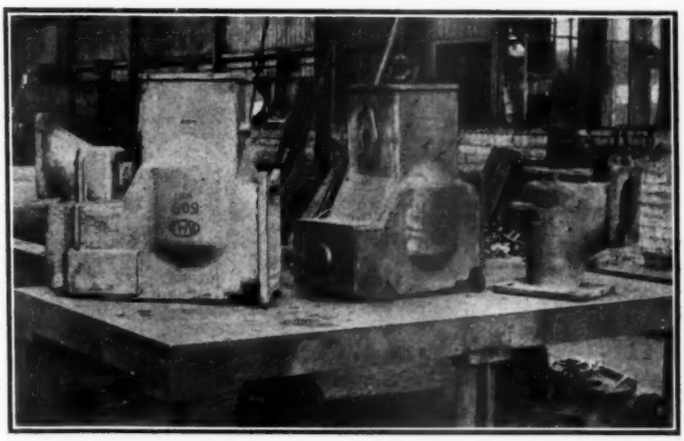

FIG. 5.—CASTINGS MADE ENTIRELY IN GREEN SAND, OF SPECIAL METAL, WITH MACHINED GAS-TIGHT FACES INSIDE.

* Paper read before the Sheffield Branch of the Institute of British Foundrymen.

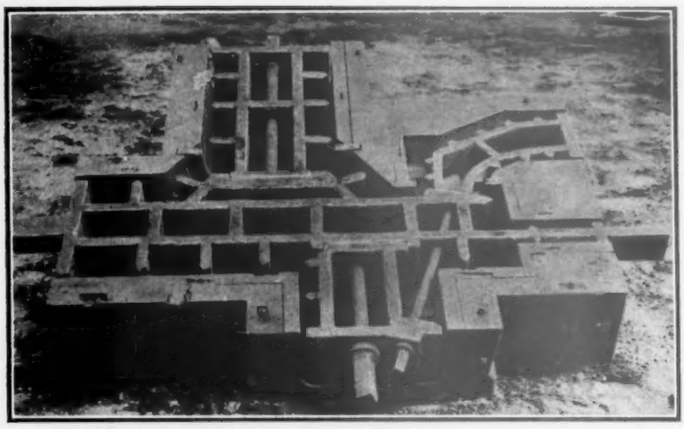

Fig. 6.—Special Core-Iron for Green-Sand Core, Core-Box having Loose Sides.

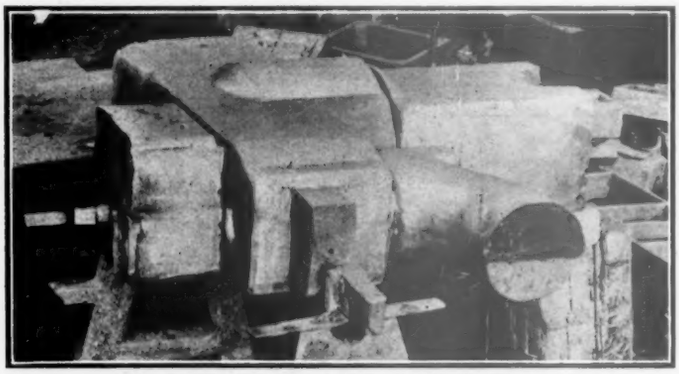

Fig. 7.—Green-Sand Core ready for Mould.

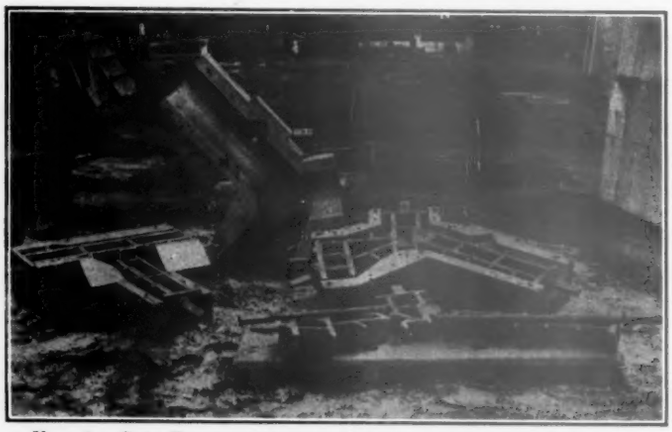

Fig. 8.—Core-Box and Special Core-Iron, showing means of assembling Core-Iron Segments.

Fig. 9.—Arch-Pipe with Green-Sand Core.

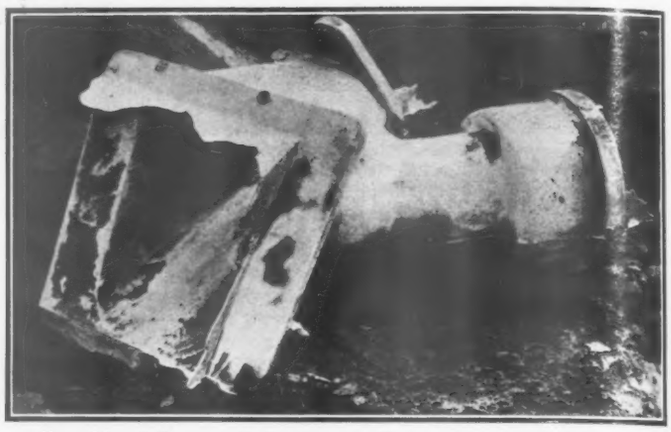

Fig. 10.—"Offtake" Casting of Unusual Design, made in Green Sand.

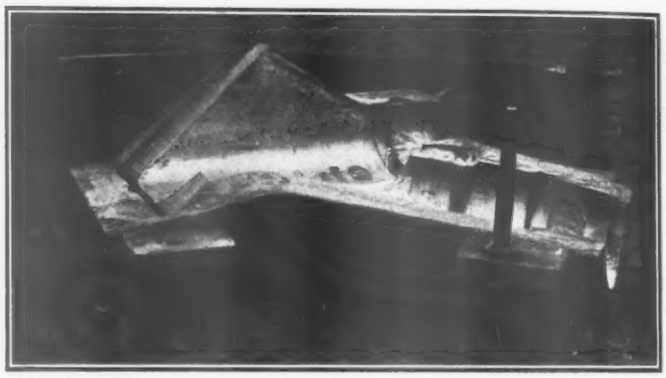

Fig. 11.—Mould for Offtake Casting, showing Special Box Used.

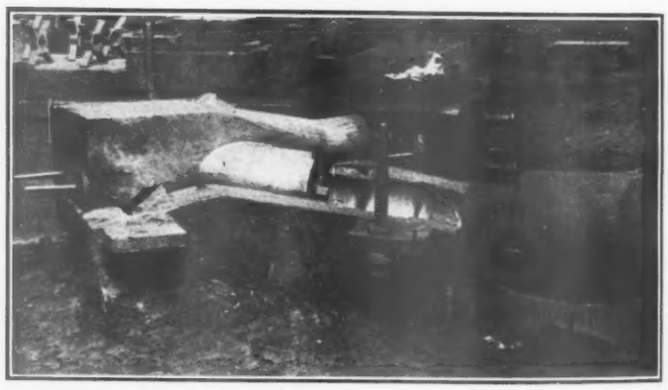

Fig. 12.—Mould for Offtake Casting with Green-Sand Core in Position.

Fig. 13.—Mould for Offtake Casting ready for Top Part.

Fig. 2 shows a "beater" for a paper mill, the overall sizes being roughly 13 ft. 6 in. by 7 ft. 6 in. by 3 ft., with a wall thickness of $\frac{5}{8}$ in. The top side, as shown, is the bottom side as cast. The inside of the casting is tiled before being put into service; the buttons that can be observed are designed to assist the cement to stay in position. These castings are not always made in green sand. Various firms either dry or skin-dry the moulds, but with the proper care there is no necessity to go to this trouble. Indeed, drying the inside of the mould has led more than once to a cracked casting. This particular casting is run by eighteen $\frac{1}{2}$-in. dia. down runners on the top at each end.

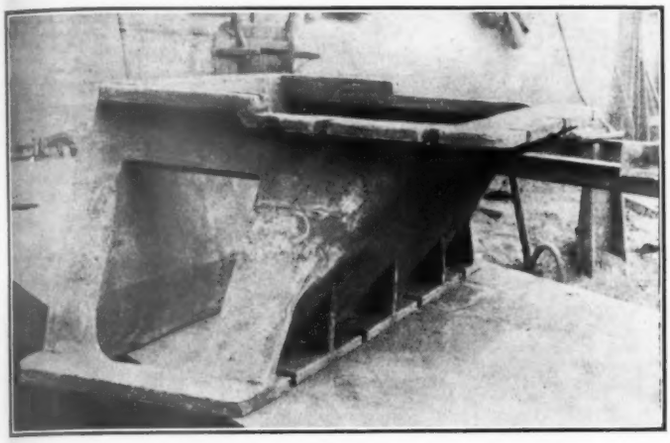

Fig. 14.—Hopper-Foot Casting for Gasworks Plant.

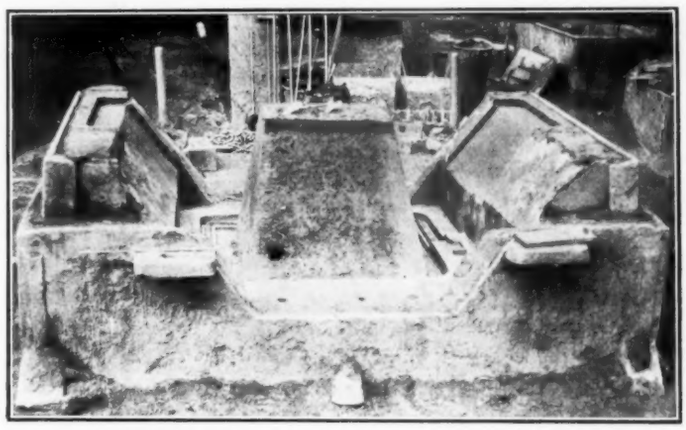

Fig. 15.—Hopper-foot Mould, showing Special Box and Moulding Method.

The best illustration of green-sand practice comes from the light-castings industry, where practically all cores as well as moulds are made of green sand. If this were not the case a light-castings foundry would have a very formidable problem in respect of stoves and handling for cores.

Fig. 5 shows three engineering castings to which this principle of a green sand core has been applied. The castings must be of satisfactory surface, soundness and finish. They are machined, and in two instances there is a gas-tight joint to be made inside, which is vital. The weight ranges from $1\frac{1}{2}$ cwts. to $5\frac{1}{2}$ cwts.

The significant feature of the attempt to make the cores for these castings in green sand lies in the provision of a special type of core-iron. The principle of its design is that it shall be so fabricated that it can be taken out of the casting fairly easily, re-assembled and used repeatedly. Fig. 6 illustrates such a core-iron. In practically every other aspect the tackle for this job is as it would be for dry sand, the one difference being that in this particular illustration the sides of the core-box are made loose. There is a core-iron only in the bottom half of the core; the upper half is without reinforcement of any kind. Fig. 7 shows a green-sand core out of that core-box ready for the mould. The practice is for the moulder to make his own cores in his own sand heap. Figs. 8 and 9 provide further illustrations of the green-sand core principle, Fig. 8 illustrating the core-iron in pieces, and assembled.

Fig. 10 shows another casting made entirely in green sand, and Figs. 11 to 13 depict various stages in manufacture. The purpose of these illustrations is to draw attention to the adoption of specially-shaped boxes in addition to the use of a specially-designed core iron for green-sand manufacture. The decision concerning the provision of tackle for such a job must be based on economic reasons rather than moulding principles. The quantity off is all-important, and the type of moulder employed is of serious consequence.

A new firm attempting these methods could hardly hope for the success enjoyed by the author's firm, as with the latter the contention is that, by providing a specially-shaped box, they can save from a half to two-thirds the moulding time, and that by utilising green-sand cores they can save half the core-making time. Usually there is no doubt that an order for twelve will repay for the provision of this special tackle, and there are instances where even six represent an economic proposition.

There is no special secret in the making of green-sand cores. It is not a job for an unskilled worker, of course, but with the proper type of sand and a little practice, almost any moulder should be capable of producing these cores. In general the procedure is to line the core-box with a $\frac{3}{4}$-in. face of facing sand, which is made up roughly of 9 parts of floor sand to 1 of new sand, and 1 of superfine coal-dust. The core-iron is then clay-washed and dropped into the core-box. The remaining sand is usually riddled floor sand. The ramming and the venting is much the same as would be done on an ordinary core. It is the custom after finishing and blacking these cores to let them stand until the next day before using. It should be noted that the core-iron is taken out of the casting before the casting goes to the fettling shop, and thus very little sand leaves the foundry. None of the sand used on these castings is milled.

A further casting where the provision of a specially-shaped box is the economic salvation of the job is shown in Fig. 14. This casting is made in green sand, except for the addition of a number of dry-sand cores, and in this case also the moulder makes his own cores. Figs. 15, 16 and 17 show the progressive development of the job. The amount of time saved by the provision of special boxes can best be estimated from the fact that a man and a boy produce four such castings per week, complete with cores. The facing sand is hand-mixed and no auxiliary labour is provided. There is, however, in addition to the tackle shown, a turning-over board which eliminates all joint-making.

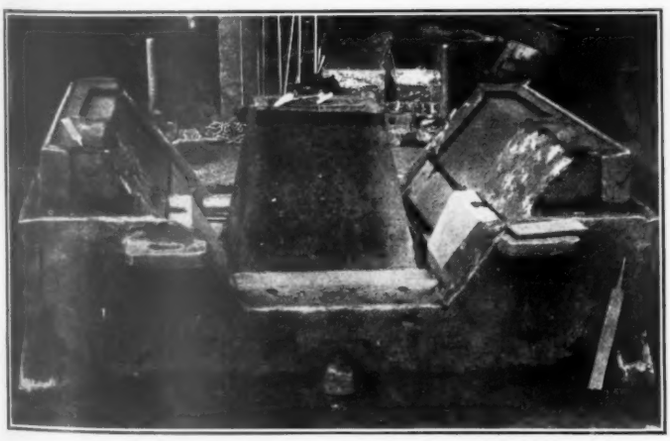

Fig. 16.—Hopper-Foot Mould with First Cores in Position.

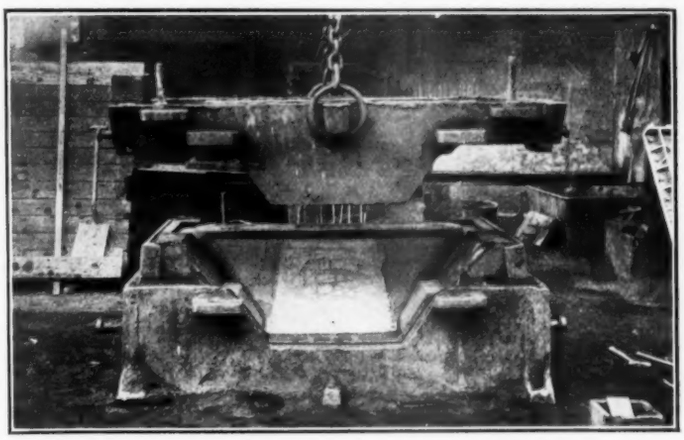

Fig. 17.—Mould for Hopper-foot Casting ready for Closing.

(To be concluded.)

E

Fluidity-Temperature Relations of Cast Steels of Various Compositions*

By R. J. SARJANT, D.Sc., and T. H. MIDDLEHAM (Sheffield)

The investigations described in Section II, Part B, of the Third Steel Castings Report refer to experiments on the relationship between the fluidity and temperature of various compositions of steel. The method used to determine the fluidity was that originally proposed by Ruff,[1] and developed as a melting-shop test by the members of the Steel Castings Research Committee.

It had been realised that from the standpoint of foundry practice there existed a need for a test which, whilst serving as an accurate index of the suitability of the metal for a given casting operation, would be capable of ready application under melting and casting-shop conditions. The mould proposed by Ruff has marked advantages from these points of view, in that it is capable of being readily made and applied, and requires the service of only a relatively small quantity of metal. If the results of this test could be shown to give the necessary standard of accuracy, reproducibility and relationship to the established principles which govern the fluidity of molten metals, then a new and valuable instrument for gauging the casting characteristics of a metal would have been put into the hands of the founder.

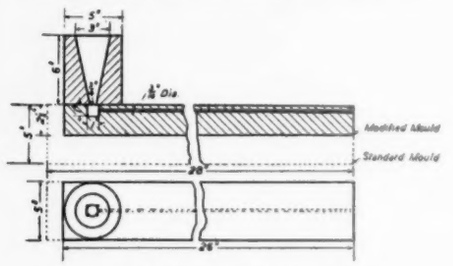

FIG. 1.—SECTION OF MODIFIED RUFF MOULD.

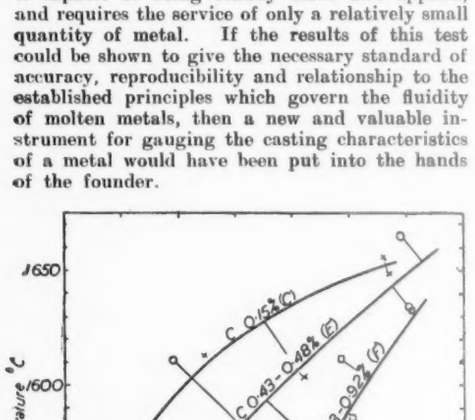

FIG. 4.—TEMPERATURE-FLUIDITY DIAGRAM FOR CARBON STEELS, WITH 0.15, 0.45 AND 0.9 PER CENT. CARBON (STEELS C, E AND F).

Accordingly, these experiments serve not only to provide information on the fluidity of various steels, and to supplement other researches carried out under the auspices of the Committee, but they also provide an examination of the suitability of the method proposed as a practical test of the fluidity of molten metal.

The investigations cover:—(1) A series of experimental trials on steels of various compositions under closely controlled conditions as regards temperature and pouring of the metal; and (2) works trials under normal conditions of industrial practice. In this series a comparison has been made of the two forms of trial on steels of approximately the same composition.

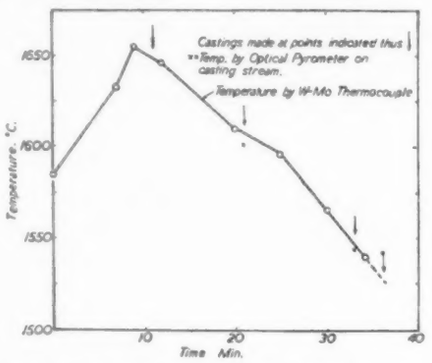

FIG. 2.—TYPICAL TEMPERATURE-TIME CURVE, SHOWING INCIDENCE OF CASTING OF THE TEST-PIECES.

TABLE I.—*Physical Characteristics of the Moulding Material Used.*

Condition of mould.	Moisture. Per cent.	Apparent density. G. per c.c.	A.F.A. permeability No.	Crushing strength. Lb. per sq. in. (A.F.A.).
Green ..	2.0	1.60	150	3.8
Dried at 200 deg. C. ..	—	—	180	783

TRIALS IN AN EXPERIMENTAL HIGH-FREQUENCY MELTING UNIT

In order to obtain exactly reproducible conditions of melting and casting, an experimental high-frequency melting furnace of 20 lbs. capacity has been used. The moulds have been constructed from standard materials in a routine manner, and the conditions of pouring have been maintained constant by the use of a special casting trolley. The raw materials for melting have been kept as far as practicable similar, and the sequence of operations as regards time of melting, procedure and time of pouring has been kept standard in successive heats.

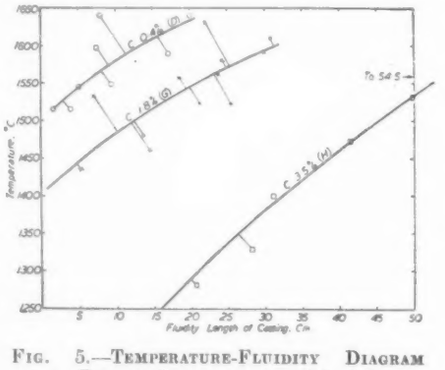

FIG. 5.—TEMPERATURE-FLUIDITY DIAGRAM FOR CARBON STEELS, WITH 0.4, 1.8 AND 3.5 PER CENT. CARBON (STEELS D, G AND H).

The Ruff mould was made in an oil core sand, consisting of 82 per cent. of Chelford silica sand, 13.7 per cent. of Worksop red, 1.6 per cent. of dextrine, 1.2 per cent. of wood extract and 1.5 per cent. of oil, and dried at 200 to 230 deg. C. for 4 hrs. The physical characteristics of the moulding material are stated in Table I.

The dimensions of the mould as used in the earlier experiments are shown in Fig. 1. Later it was found that the size of the mould could be reduced to 26 in. long by 5 in. wide by 2½ in. deep without interfering in any way with the effectiveness of the test. The essential feature of the mould was the provision of a horizontal flow channel ⅞ in. in dia. and 21½ in. long. This was fed from a conical head, through a gate of standard design and dimensions. The runner head was made separately in the same oil sand, and was merely placed in position on the mould. No jointing material or external reinforcement of the mould of any kind was necessary—that is to say, that the mould and head were used without the need for any moulding boxes. The mould was reinforced internally by means of two ⅜-in. iron rods. This was a safeguard against breakage in handling.

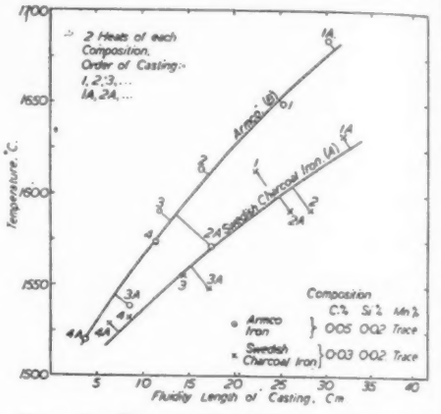

FIG. 3.—TEMPERATURE-FLUIDITY DIAGRAM FOR VERY LOW CARBON STEELS (STEELS A AND B).

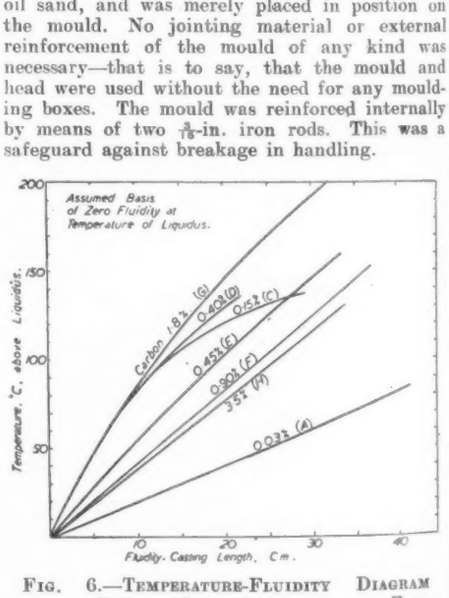

FIG. 6.—TEMPERATURE-FLUIDITY DIAGRAM FOR CARBON STEELS RELATED TO ZERO FLUIDITY AT TEMPERATURE OF LIQUIDUS.

Casting Carriage.—The provision for ensuring a constant pouring head of molten metal was obtained by placing the mould on a casting carriage. This was provided with small wheels to enable it to be moved forward on a fixed platform a distance of 6 in. so that as the crucible containing the molten metal was tilted on its trunnions in the casting operation, the

* This Paper was included as part of the Third Steel Castings Report presented at the Autumn Meeting of the Iron and Steel Institute in London last week.

stream of metal was directed constantly into the centre of the head.

Pouring Conditions.—The mould was mounted horizontally to give a fixed mean height of the casting stream above the top of the casting head of 2½ in.

Melting.—The melting was carried out in a high-frequency induction furnace of 30 k.v.a. capacity, using sillimanite crucibles. A charge of 20 lbs. was sufficient for four tests, which were cast at different temperatures. The sequence of trials and the variation of temperature in successive tests is shown in Fig. 2, which represents a typical record of the temperature observations made.

Temperature Measurement

Throughout the test, temperatures were taken in the bath by means of a tungsten-molybdenum thermocouple, using a potentiometer. The couple was protected by a small silica sheath. Immersions of about ½ min. duration were adequate to give reliable temperature measurements of the steel in the molten bath. Observations were made at frequent intervals, and always immediately before and after casting. This couple was calibrated against the melting points of copper, nickel, pure iron and platinum, and its stability with continued immersion was established by rechecking after use. Although the sheathed section of the couple developed embrittlement as the result of service, no change in calibration occurred. A sheath was used on the average eight to ten times, and on being discarded a length of 4 in. of wire was broken off and a new junction made.

The temperature of the metal was also measured for comparison by means of optical pyrometers of the disappearing-filament type. The apparent temperatures reported were taken on the casting stream as it entered the mould. In some cases there was some divergence between the corrected temperature and the temperature indicated by the thermocouple. It has been established that the emissivity values

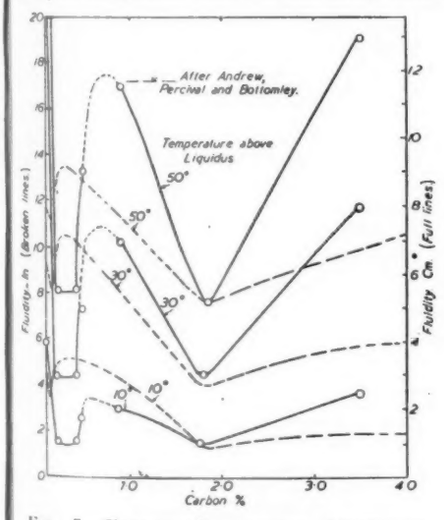

FIG. 7.—FLUIDITY-COMPOSITION CURVES OF CARBON STEELS FOR TEMPERATURES 10, 30 AND 50 DEG. C. ABOVE LIQUIDUS.

of molten steels do not always accord with the generally accepted figure of 0.40. The differences noted have always occurred in steels in which such change of emissivity with temperature is likely to occur, for example, in steels containing aluminium or copper.

The accuracy of calibration of the couple was within ± 1 deg. C. of the accepted temperature scale, and, taking into consideration the limitations imposed by the time lag in the sheathed couple, it is believed that the actual temperatures obtained are within ± 3 deg. C. of the true value.

Composition of the Steels Used

The chemical composition of the steels tested was checked by means of analyses of individual fluidity test-pieces. Since the results cover a number of heats of the same approximate composition the limits of the range of composition are detailed in Table II. Due to the circumstance that it was necessary to hold the molten steel in the crucible for the time necessary to complete the series of trials, occasionally it was found on analysis of the test-piece that some loss of either carbon or some other readily oxidised constituent occurred. Due note has been taken of any such occurrence in the interpretation of the results. A note of the actual compositions found in such cases is given in the last column of Table II. The sulphur and phosphorus were in all cases kept low.

Results

The results of the experiments are shown in a series of fluidity-temperature diagrams, Figs. 3 to 6 and 9 to 14. It was apparent that under the conditions prevailing a relationship existed between the fluidity of the steel and the temperature. The points shown on the diagrams cover all the experiments made, and therefore the maximum degree of experimental error met with is disclosed. It will be seen that in certain cases the divergence of individual tests is wide, but these must be ascribed to differences in the pouring or other experimental conditions. In some cases, for example in the experiments detailed in Fig. 13, the relationship shown by the plot of the experimental points is remarkably good, the maximum divergence of the points from the mean curve being equivalent to 3 deg. of temperature, or 1 cm. of length of test-piece.

Carbon Steels

In Fig. 3 are shown the results obtained with two types of ingot iron, described for the purpose of this research as "very low-carbon steels." The points plotted refer in each case to two heats, and the order of casting is shown by the reference numbers 1, 2, 3 . . . and 1A, 2A, 3A. . . . The differences of fluidity revealed

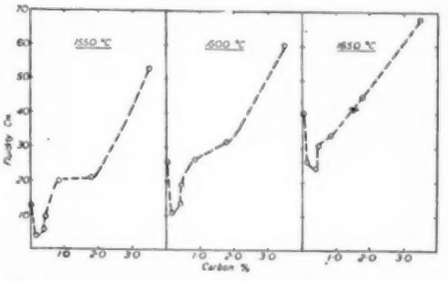

FIG. 8.—FLUIDITY-COMPOSITION CURVES OF CARBON STEELS FOR TEMPERATURES OF 1,550, 1,600 AND 1,650 DEG. C.

are particularly interesting, since the two materials are of almost identical composition as regards the contents of carbon, silicon and manganese. The divergence of the curves at the higher temperatures is also noteworthy, and is a fact which must be considered in relation to the differences in the composition of the materials as regards their oxygen content.

The carbon steels considered have contained such proportions of carbon as to make it possible to compare them with the results obtained

TABLE II.—*Chemical Composition of Steels Used.*

Ref. no.	Description.	Composition. Per cent.					Remarks.
		C	Si	Mn	Cu	Al	
A	Swedish charcoal iron	0.02–0.04	Trace–0.02	Trace	—	—	
B	Armco iron	0.05–0.06	0.02	Trace	—	—	
C	0.15 per cent. carbon steel	0.15	0.05	0.20	—	—	
D	0.4 per cent. carbon steel	0.39–0.44	0.03–0.07	Trace	—	—	
E	0.45 per cent. carbon steel	0.43–0.48	0.03–0.07	Trace	—	—	
F	0.90 per cent. carbon steel	0.83–0.92	0.09–0.11	0.02–0.06	—	—	
G	1.80 per cent. carbon steel	1.8–1.9	0.09–0.11	0.03–0.06	—	—	
H	3.5 per cent. carbon steel	3.2–3.78	0.10	0.05	—	—	
J1	0.15 per cent. C + 0.05 per cent. Al addition	0.11	0.03	0.08	—	0.013	
J2	0.15 per cent. C + 0.10 per cent. Al addition	0.16	0.03	0.06–0.08	—	0.027	
J3	0.15 per cent. C + 0.30 per cent. Al addition	0.14	0.02	0.06–0.08	—	0.10	
K1	0.15 per cent. C + 0.30 per cent. Si	0.12–0.13	0.30	0.06	—	—	One test-piece showed low Si, 0.06 per cent.
K2	0.15 per cent. C + 0.50 per cent. Si	0.14	0.45	0.18	—	—	
K3	0.15 per cent. C + 0.75 per cent. Si	0.17	0.70–0.63	0.15	—	—	
K4	0.15 per cent. C + 1.00 per cent. Si	0.15	1.00	0.40	—	—	
L1	0.15 per cent. C + 0.40 per cent. Mn	0.13	0.05	0.39	—	—	
L2	0.15 per cent. C + 0.75 per cent. Mn	0.10–0.18	0.16	0.94–0.72	—	—	One test-piece showed Mn, 0.37 per cent.
L3	0.15 per cent. C + 1.00 per cent. Mn	0.15	0.11	0.95	—	—	
M	13 per cent. manganese	1.3–1.38	1.0–1.4	10.65–12.15	—	—	Some variation of Mn due to reaction with lining of crucible.
N1	0.15 per cent. C + 1.0 per cent. Cu	0.07–0.14	0.08	0.20–0.03	1.05–1.09	—	Low Mn in one test-piece.
N2	0.15 per cent. C + 2.0 per cent. Cu	0.12–0.14	0.06–0.02	0.11–0.09	1.89–1.93	—	
O	Copper steel with 0.5 per cent. Si + 0.5 per cent. Mn	0.11	0.57	0.48	1.80	—	

by Andrew, Percival and Bottomley,[3] on the basis of the diagrams presented in their Paper. The actual experimental results, recorded on the usual direct basis of fluidity-temperature, are shown in Figs. 4 and 5.

In several of the diagrams discussed it will be noted that extrapolation of the experimental curves to zero fluidity would give values on the temperature ordinate below the liquidus temperature. This would suggest that the assumption of the existence of zero fluidity at the temperature of the liquidus cannot be strictly correct, though it may provide a useful means of exhibiting relationships between fluidity characteristics and those disclosed by the equilibrium diagrams of the materials in question. The work of Portevin and Bastien,[3 4] as well as that of Andrew and his collaborators, has indicated the scope of the method.

In Fig. 6 the curves of the series of carbon steels have been drawn on this basis, and from this diagram that of the fluidity-composition (Fig. 7) has been constructed. On this diagram has been superimposed the one reported by Andrew, Percival and Bottomley, in the Committee's Second Report[3] in such a manner as to make the points for 1.8 per cent. carbon steel at 50 deg. C. above the liquidus coincide. Whilst there is a general agreement as to the form of the fluidity-composition curves, there is a difference in the location of the peak in the curve, which in the case of the dotted curve corresponds to the peritectic point in the iron-carbon diagram.

Fig. 8 shows the relation between the temperature, composition and fluidity for the above range of carbon steels.

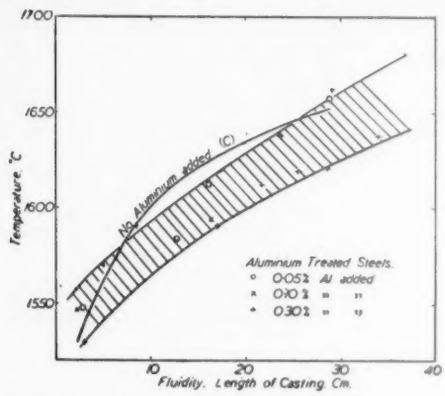

FIG. 9.—TEMPERATURE-FLUIDITY DIAGRAM FOR 0.15 PER CENT. CARBON STEEL, WITH ADDITIONS OF 0.05, 0.10 AND 0.30 PER CENT. AL (STEELS J1, J2 AND J3).

Aluminium Additions

The effect of additions of aluminium has been to produce an improvement in the fluidity of 0.15 per cent. carbon steel, but not in proportion to the amount added. Comparatively small percentages of the addition made were present in the castings as aluminium, the yield naturally falling off in the later castings from any individual melt. The fluidity is not proportional to the residual aluminium. The condition of the steel as regards oxidation is probably a factor affecting the fluidity. Whatever may be the specific influence of aluminium alone, there appears to be an additional influence due to its deoxidising action. Accordingly, the actual effect of the added aluminium probably depends on the condition of the steel before the addition. The results are shown in Fig. 9. The behaviour of the steels containing aluminium is in accordance with Ruff's results.

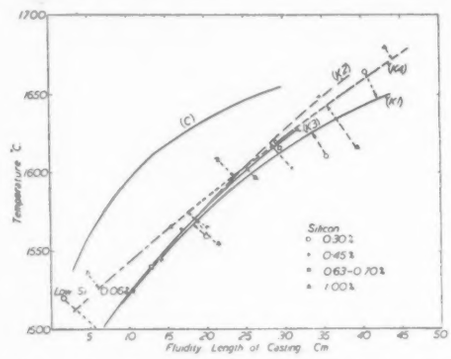

FIG. 10.—TEMPERATURE-FLUIDITY DIAGRAM FOR 0.15 PER CENT. CARBON STEEL, WITH 0.30, 0.50, 0.75 AND 1 PER CENT. SI (STEELS K1, K2, K3 AND K4).

Silicon Additions

The addition of silicon to 0.15 per cent. carbon steel, as shown by the temperature-fluidity curves in Fig. 10, increases its fluidity in relation to the temperatures usually ruling in steel foundry practice, but not proportionally to the percentage of silicon added, the range of additions made covering from 0.3 to 1.0 per cent. of silicon, having an approximately similar influence. It will be observed that some of the experimental points do not fall on the curves of relationship shown. This may be due to the fact that silicon additions may resemble those of aluminium in providing a contributory factor to affect the fluidity by reason of the influence of the element on the state of deoxidation of the bath. The effect of silicon in increasing the fluidity appears to be greater at the lower temperatures than that of aluminium.

Manganese Additions to 0.15 per cent. Carbon Steel

Increased fluidity results from the addition of manganese to 0.15 per cent. carbon steel, as shown by the temperature-fluidity diagrams in Fig. 11. At the lower end of the temperature scale the magnitude of this influence increases with rising manganese, but as the amount of the addition becomes greater, the slope of the temperature-fluidity curve becomes steeper, so that in the neighbourhood of 1,625 to 1,640 deg. C. the curves coincide, and at higher temperatures the reverse order prevails.

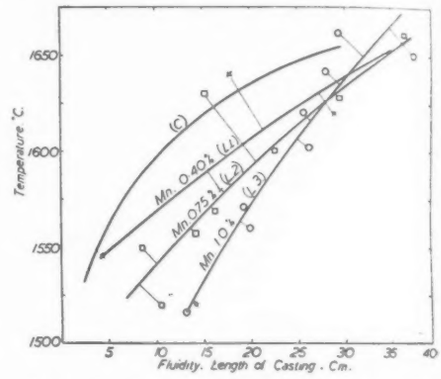

FIG. 11.—FLUIDITY-TEMPERATURE DIAGRAM OF 0.15 PER CENT. CARBON STEEL, WITH 0.40, 0.75 AND 1.0 PER CENT. MN (STEELS L1, L2 AND L3).

Comparing these curves with those relating to silicon additions, it will be noted that for small additions (0.5 per cent. of manganese) the degree of increase in fluidity is less with manganese than with a corresponding silicon addition; 0.7 per cent. of manganese is roughly similar in effect to 1.0 per cent. of silicon at about 1,550 deg. C., but is less effective at higher temperatures. The higher manganese content, 1.0 per cent., more effective than silicon at low temperatures, is inferior at temperatures above about 1,600 deg. C. Attention has been directed to these comparisons because the founder is mainly interested in the values of absolute fluidity as indicated by a test which is related to the conditions of flow in casting in the temperature range usually experienced in steel foundry practice. This range of temperature is between 1,550 and 1,670 deg. C.

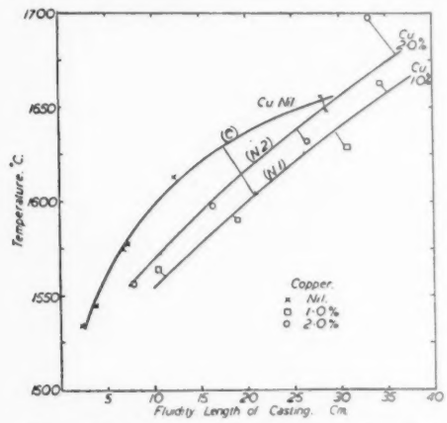

FIG. 12.—FLUIDITY-TEMPERATURE DIAGRAM OF 0.15 PER CENT. CARBON STEEL, WITH 1 AND 2 PER CENT. CU (STEELS N1 AND N2).

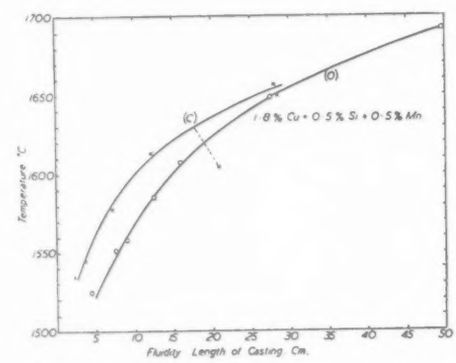

FIG. 13.—FLUIDITY-TEMPERATURE DIAGRAM OF 2 PER CENT. COPPER STEEL, WITH 0.5 PER CENT. SI AND 0.5 PER CENT. MN (STEEL O).

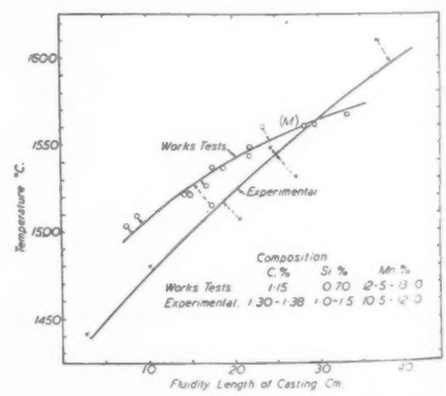

FIG. 14.—FLUIDITY-TEMPERATURE DIAGRAM OF 13 PER CENT. MANGANESE STEEL. COMPARISON OF WORKS AND EXPERIMENTAL TRIALS (STEEL M).

Copper Steels

The results obtained on two steels containing 0.15 per cent. of carbon with 1.0 and 2.0 per cent. of copper, respectively, are shown in the temperature-fluidity curves in Fig. 12. Both

compositions have a higher fluidity value than the plain carbon steel over the range of temperatures investigated. The form of the two curves is similar, but with the 1.0 per cent. copper steel showing consistently better fluidity than that containing 2.0 per cent. of copper.

The behaviour of another copper steel, also with 1.8 per cent. of copper, but containing in addition about 0.5 per cent. each of silicon and manganese, is shown in Fig. 13. This fluidity-temperature curve resembles very closely that of the corresponding steel without the silicon and manganese additions.

WORKS TRIALS

Trials of this method of determining the fluidity have also been carried out on an industrial scale in the steel foundry. The fluidity tests were cast from spoon samples taken from a basic electric furnace, just prior to pouring. Samples have also been taken from ladles and shanks. The temperatures were observed by means of an optical pyrometer of the disappearing-filament type as the steel was poured into the fluidity mould.

The results of a series of trials taken on a class of steel which gave consistent values of emissivity, enabling the true temperature of the molten steel to be measured, are shown in Fig. 14. The observed points given in the diagram show a reasonable relationship between the fluidity and temperature. In order to correlate the results of the experimental research described in Section II B of the Report with those of works trials, steels of approximately the same composition were melted in the experimental high-frequency unit. Comparison of the results is shown in Fig. 14. A higher carbon and silicon content is shown in the experimental steels, which may account for the difference of fluidity revealed.

Numerous works trials have also been made of the method applied to steels of other compositions. This experience has shown that the method has the necessary simplicity and convenience for a works test. The results obtained have given indications of fluidity which have proved reliable in judging the suitability of the running characteristics of a steel for a given casting operation.

Conclusions

(1) The experimental investigations reported indicate that the method of testing fluidity described gives a definite relationship between the fluidity of cast steel and its temperature. The results are reproducible within limits which are sufficiently accurate for practical purposes.

(2) The fluidity-temperature relations as determined by the method have shown the following:

(*a*) *Very Low-Carbon Steels.*—Two materials of practically identical compositions as regards their content of carbon, silicon and manganese, namely, Armco iron and Swedish charcoal iron, showed divergences of fluidity to be attributed to their differences of composition in other respects, *e.g.*, oxygen.

(*b*) *Carbon Steels.*—The general form of the fluidity curves governing the behaviour of these steels, which was communicated in the Committee's Second Report on the indications of a spiral form of test-piece, has been confirmed, with the exception of some divergence in the compositions corresponding to the peaks in the fluidity-composition curves for specified degrees of superheat above the liquidus temperature.

(*c*) Additions of small amounts of aluminium (up to 0.3 per cent.), of silicon (up to 1 per cent.), and of manganese (up to 1 per cent.) confer increased fluidity on low-carbon steel. The contributory influence of the state of deoxidation of the steel is discussed.

(*d*) Additions of copper (up to 2 per cent.) produce only a slightly increased fluidity, which in the case of a 2 per cent. content of copper is not increased by further additions of silicon (0.5 per cent.) and manganese (0.5 per cent.).

(3) Practical trials in the steel foundry have shown the method to have the necessary simplicity and convenience for industrial purposes, and to give pertinent information regarding the running characteristics of a steel for a given casting operation.

Acknowledgments

The authors cordially acknowledge their indebtedness to Mr. W. J. Dawson, the chairman of the Research Committee and metallurgical director of Hadfields, Limited, at whose suggestion this research was undertaken, and thank him for his continued interest and help during its prosecution. Their thanks are also due to Mr. W. J. Todd for help in connection with the calibration of the pyrometers used.

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Notes from the Branches

Lancashire Branch Junior Section.—The annual meeting of the Lancashire Branch Junior Section of the Institute of British Foundrymen was held at the Manchester College of Technology on October 21, the retiring President, Mr. A. Hopwood, being in the chair.

The SECRETARY (Mr. O. Bateson), presenting his annual report, said that the last session showed an improvement over previous sessions, the attendances at the meetings having averaged twenty. Their sincere thanks were due to Mr. A. Hopwood, who had been an ideal President in every respect. Valuable and instructive Papers had been delivered at each meeting, and the Section was indebted to those gentlemen who gave the benefit of their experience and knowledge to the members. The Section still managed to pay its way without the help of the parent Branch, and if members would pay subscriptions when they were due the Section would continue to be quite sound financially.

If each member would try to bring in a new recruit the Section membership would be comparable with the times when there was a regular attendance of 50 members. Boys in the trade must be shown that it was to their future benefit as craftsmen that they should attend junior meetings, listen to lectures, and take part in discussions. In conclusion, the Secretary expressed thanks to the members of the Council for their valuable assistance during the past session.

The Report was adopted, and a hearty vote of thanks was accorded to the Secretary on the motion of MR. HOPWOOD.

The new President, MR. R. R. HARGRAVES (Ashton-on-Mersey), was then installed in the chair, and he assured members that he would endeavour to fulfil the duties of the office with the same dignity and success as had been achieved by his predecessors.

Referring in the course of his address to education, Mr. Hargraves emphasised that the main point was to interest the student in his craft, and to give him at least some elementary knowledge of the constituents of metals and raw materials, together with the proper methods of treatment. It was especially in the favour of members of the Institute that such technical and practical training was organised. The facilities which were provided for obtaining technical instruction could not be recommended too strongly, and, together with the added advantage of hearing practical views and experiences expressed, it would enable members to glean the necessary fundamental principles for their future guidance.

The series of lectures provided during the session was of a comprehensive nature, and he thought they would be greatly appreciated by all who had the pleasure of participating in them. They would also find, as he had done during his 19 years membership of the Institute, that a valuable and esteemed association of personal friends would be formed through continual contact at the meetings and other social functions in connection with the Section.

The President then proposed a vote of thanks to the retiring officers, and spoke of the capable and efficient manner in which Mr. Hopwood had carried out his duties. He had been a most energetic President, and had done his utmost to fulfil the duties of his office to the best advantage of the Section.

The vote of thanks was seconded and carried unanimously.

The following officers were re-elected:—*Hon. Secretary*, Mr. O. Bateson; *Hon. Treasurer*, Mr. A. Boyes; *Council*, Messrs. A. G. Adams, A. Flower, J. Hill, C. Jones, F. Royle, and C. Sutcliffe.

A Paper on "Green-Sand Moulding and Skin-Dried Moulds" was then presented by Mr. A. Sutcliffe, who illustrated his remarks with lantern slides and specimens of work from his own shop. The Paper was on practical lines, and dealt with the difficulties of particular jobs, and the way in which such difficulties were overcome.

A vote of thanks to the lecturer, proposed by MR. FLOWER and seconded by MR. HILL, was carried unanimously. Time did not permit of a full discussion of the Paper.

Publication Received

Handbook of Structural Steelwork (1938 Edition). Issued by Redpath Brown & Company, Limited, of Edinburgh, London, Manchester, and elsewhere.

Recipients of this 500-page book can indeed count themselves fortunate. It would be imagined by *hoi polloi* that a designer would have at the side of his drawing board ponderous textbooks dealing with safe loads, stresses and strains, yet the truth is he finds that this particular book covers 95 per cent. of his needs. A hundred pages or so cover in the most comprehensive fashion the subject of beams, and a similar amount of space is devoted to columns. Then almost up to page three hundred is a variety of tables covering British Standard sections, angles, overhead cranes, roof trusses, gutters, and fall pipes (sizes and spacing), nuts and bolts, and weights of materials. The next section—about 85 pages—is given over to general notes and formulæ, whilst the balance is devoted to mathematical tables—logarithms and the like—photographs and an appendix which extracts some B.S.I. specifications. Finally there is an excellent index.

Catalogue Received

Moulding-Sand Testing Machines. Sand-testing machinery is developing so rapidly that it is not easy to keep up to date. For this reason Leaflet No. 199 just issued by Ridsdale & Company, Limited, of 3, Wilson Street, Middlesbrough, is most welcome. It is probably as unique in character as it is comprehensive. The 3rd Steel Castings Report has underlined the necessity for still further standardisation, and the apparatus so well described and adequately illustrated in this pamphlet only embraces designs of a standardised character. We feel sure most of our readers will esteem this catalogue as a really useful contribution to their technical and industrial needs.

The Iron and Steel Institute

AUTUMN MEETING IN LONDON

The Autumn Meeting of the Iron and Steel Institute was held at the Institution of Civil Engineers, Great George Street, Westminster, on October 26. In the absence of the President, Lord Dudley, in America, the chair was taken by Sir Harold Carpenter, F.R.S. (Past-President).

Election of Members.—Messrs. P. W. Wood and A. G. Hock were appointed scrutineers of the ballot for the election of new members, and later in the meeting it was announced that all the 99 candidates had been elected, and a vote of thanks was accorded to the scrutineers.

Message from Germany

The CHAIRMAN announced that a telegram had been received from the Verein deutscher Eisenhüttenleute, signed by Professor Goerens and Dr. Petersen, of which the translation read: "We send sincere greetings to the Council and members of the Iron and Steel Institute, and best wishes for the success of the Autumn Meeting." On behalf of the Institute, he expressed the appreciation felt for that message.

Obituary

The CHAIRMAN said it was his sad duty to refer to the death of Mr. Alfred Hutchinson, which took place at Blackheath on August 20 last. Mr. Hutchinson had been President of the Institute the previous year, and the members would be glad that his long connection with the Institute—he was a member for 43 years—had concluded with the Presidency. He thoroughly enjoyed his year of office and was an extremely good President. During the whole of his career Mr. Hutchinson took a great interest in all the activities of the Institute, and his period as President was distinguished by the great personal interest which he showed in the joint meetings with local societies. Although he was not a young man—he was about 70 years of age when he took office—he always made a point of representing the Institute in person when that was at all possible. The members would sympathise with Mrs. Hutchinson and her family in their great bereavement, and would feel themselves the poorer by the loss of a very dear friend.

Continuing, the Chairman said he wished also to refer to the death of two of the Past-Presidents of the Institute of Metals, Sir Henry Fowler and Mr. W. R. Barclay.

Sir Henry Fowler, who died on October 16, was well known to many for his work on the L.M.S. Railway, and his interest in the International Association for Testing Materials. Sir Henry had not been in good health for some years, but many of those who knew him before his retirement would realise that the country as well as the Institute of Metals had lost a man of outstanding ability.

It was less than a year ago that the Iron and Steel Institute were in constant consultation with Mr. W. R. Barclay, who died on September 16 last. As President of the Institute of Metals, he was of great assistance in the negotiations which resulted in the removal of both Institutes to new offices in Grosvenor Gardens and the formation of a joint library. He would ask Dr. Desch to be good enough to convey to the Institute of Metals the deep sympathy of the Iron and Steel Institute at the loss which had been sustained by the death of Sir Henry Fowler and Mr. Barclay.

The members stood in silence for a short time as a token of respect.

The CHAIRMAN offered a welcome to members of the Institute from other countries who were attending the meeting, and also to the members of kindred societies who were present, and went on to announce that the Council had recently elected the Hon. R. G. Lyttelton and Mr. A. B. Winder as members of the Council. They had both been members of the Institute for many years and were well known to a great many of the members.

Cancellation of Joint Autumn Meeting in America

Continuing, the Chairman referred to the fact that, as was well known, arrangements had been made for the Autumn Meetings of the Iron and Steel Institute and of the Institute of Metals to be held in New York, and a joint programme of visits to Canada and the United States of America had been prepared. The political situation, however, made it necessary to cancel those arrangements two days before the first party had intended to sail in the "Empress of Britain." The members were disappointed that it had again been found impossible for the Institutes to go to America, especially as a few years ago a visit had to be postponed owing to the economic crisis. The programme on the present occasion was to have been of exceptional interest, and there was every indication of a successful meeting. The parties would have consisted of more than 300 members and ladies, and the reception which they would have received from the hospitable countries which they were to visit could be imagined. The Council hoped that it might be possible for a visit to take place another year. Their American friends had already intimated unofficially that they hoped it would be possible for the programme to be taken up on another occasion, but it was not yet known whether a visit next year would be convenient.

He would like to record the gratitude of the Council to the Canadian Institute of Mining and Metallurgy, the American Iron and Steel Institute and the American Institute of Mining and Metallurgical Engineers for all the work which they did in connection with the intended visit, and the deep regret which was felt at the inconvenience and disappointment which the change in plans must have caused them.

Additional Autumn Meeting in Cardiff

In addition to the present meeting, the Iron and Steel Institute had been fortunate enough to receive an invitation to hold an additional Autumn Meeting in Cardiff, and he believed that invitation originated with Mr. J. S. Hollings, a Vice-President of the Institute and joint managing director of Messrs. Guest Keen Baldwins Iron & Steel Company, Limited. It had been arranged to hold a meeting on the evening of Friday, December 2, at Cardiff, in the building of the South Wales Institute of Engineers, when the following two Papers would be presented: "American Soaking Pit and Reheating Furnace Design and Practice," by F. M. Gillies and E. D. Martin, and "The Development of the Open-Hearth Steelmaking Processes in Recent Years in the United States of America," by L. F. Reinartz. On the morning of Saturday, December 3, a visit would be paid to the East Moors Works of Messrs. Guest Keen Baldwins. He thought that the meeting would be of considerable interest, and the Institute owed a debt of gratitude to Sir Charles Wright, Mr. Hollings and the company for permission to visit the works. Those works had been to a large extent rebuilt in recent years, and the members attending would have the opportunity of seeing one of the finest melting shops, cogging mills and continuous billet mills in the country.

Continuing, the speaker said he thought that the experiment of holding an additional Autumn Meeting in a local centre was an important innovation, because it showed the desire of the Council to provide opportunities for members to keep in touch with local developments. The work which the local institutes did in different centres was well known and was of the greatest importance. Those institutes were entirely independent, and they had their own traditions and field of activity. Some of them were older than the Iron and Steel Institute itself. The Council were pleased that it had been possible to arrange for a series of joint meetings with a number of local institutes in the same way as in past years. The arrangements would be made known later, but in the meantime he might mention that joint meetings would be held with the Staffordshire Iron and Steel Institute, the Lincolnshire Iron and Steel Institute, the Cleveland Institution of Engineers, the Manchester Metallurgical Society and the two Sheffield societies. It was hoped that arrangements for meetings with other societies would also be made.

New Offices of the Institute.—Since the last general meeting, the Institute had moved to new premises at No. 4, Grosvenor Gardens, where they had sub-let part of the house to the Institute of Metals and were sharing the committee rooms. The libraries of the two Institutes had been joined, and the joint library housed in a large reading room. It was proposed to develop the joint library into one of the chief metallurgical libraries of the country. It was believed that the move to new premises would do a great deal to make possible increased work by the Institute's staff, and would assist in increasing the value of the Institute to the industry and to those engaged in metallurgical research.

Ablett Prize.—The Council had received and accepted a generous offer from Captain C. A. Ablett, director of the Cooper Roller Bearings Company, Limited, to present a prize to the value of £50 for the best Paper on a subject connected with engineering in iron or steel works, which was presented at the Annual Meeting of the Institute in May next year, the conditions being that the author of the Paper must be a British subject employed in an iron or steel works in Great Britain or the Empire, under 35 years of age, and holding a position not higher than that of a departmental engineer. On behalf of the Council, the Chairman said he would like to thank Captain Ablett for that generous offer, and he understood that if the response next year was favourable, Captain Ablett proposed to renew the prize for the future.

The meeting then proceeded to the presentation and discussion of Papers.

London and Sheffield Foundrymen's Joint Meeting

The London and Sheffield Branches of the Institute of British Foundrymen are to hold a joint meeting in London on November 25 and 26. The plans include a visit to the Sterling Manufacturing Company's works at Cubitt Town in the afternoon of November 25, commencing at 2.30 p.m. In the evening the party will adjourn to the London Tavern in Fenchurch Street for an informal dinner and social evening. Members gifted with the talent to entertain the company after dinner will be earnestly requested to do so. The services of an accompanist will be available.

On the second day of the meeting, November 26, a meeting will be held at the Charing Cross Hotel at 10 a.m. Two Papers will be presented, one by Dr. W. D. Jones (London Branch) on "The Powder Metallurgy of Iron, with Special Reference to Pacteron," and the second by a Sheffield Branch member, details of which have not yet been announced.

Further particulars of the meeting can be obtained on application to either of the Branch-Secretaries.

Vitreous Enamelling Section

The Institute of Vitreous Enamellers

FIFTH ANNUAL CONFERENCE IN LONDON

The Institute of Vitreous Enamellers held its fifth annual conference in London, on Friday, Saturday and Sunday, October 28, 29 and 30, with headquarters at the Hotel Normandie, Knightsbridge, S.W.1.

The annual general meeting was held on Friday afternoon, and the annual banquet in the evening, when the Institute entertained a number of distinguished guests; the banquet was followed by a very enjoyable dance and cabaret. On Saturday there were two sessions for the discussion of technical Papers, and a visit to a theatre in the evening. On Sunday the members and their ladies joined in a visit to Windsor.

ANNUAL GENERAL MEETING

Mr. W. H. Whittle (Chairman of Council) presided at the annual general meeting on October 28, and was accompanied by the President (Sir Harold Hartley). The minutes of the previous annual general meeting, held in Birmingham on October 8, 1937, were read, confirmed and signed.

Annual Report

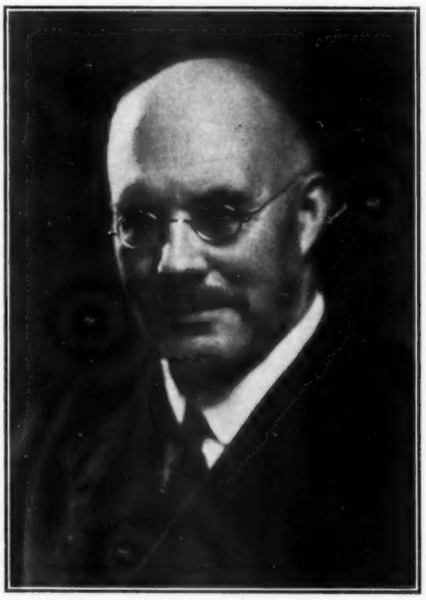
The CHAIRMAN, in his report for the past year, first recalled that the Institute had suffered the loss, by death, of Dr. J. W. Mellor (its first President), Mr. W. Noake (a member of Council), and Mr. McCalla. (The meeting observed a period of silence as a tribute to their memory.)

With regard to membership of the Institute, he said the total had reached 207, comprising 94 subscribing firms, 54 members, 35 associate members, and 24 associates—a net increase of 10 during the year. A total of 22 technical meetings had been held during the year in the four sections of the Institute, and were fairly well supported. Twenty-one lectures had been arranged for the coming session. Visits to the works of the General Electric Company, Limited, at Birmingham, Bradley & Foster, Limited, at Darlaston, and Baldwins, Limited, at Stourport, were also well supported. A further programme of visits to works had been arranged for the coming season.

The Proceedings of the Institute had been distributed, together with the Rules and Regulations which had been compiled on the basis of the Articles of Association. The registered trade sign had been adopted widely by company members of the Institute; nearly half a million of the adhesive trade sign labels had been purchased, together with a large number of trade vouchers and transfers to illustrate the trade sign.

Members of the Institute had recently returned from a tour of vitreous enamelling plants in the United States. Owing to the crisis in international affairs in September, it was decided then to cancel the arrangements for the tour; fortunately, the international situation having eased, it had been found possible for most of the original party to make the trip. He understood they had been exceptionally well received and had had a wonderful time in the United States.

The Institute had appointed Dr. G. T. O. Martin as Research Officer, and a programme of research would be carried out in collaboration with the British Cast Iron Research Association. A Committee had been formed, comprising four members of the Institute and four representatives of the British Cast Iron Research Association, and they were going ahead with the work as fast as funds would allow. The trade in general must anticipate competition; hence the appointment of Dr. Martin as research officer. The amount of money available for the purpose in the Institute was limited, of course; the rates of subscription, which were fixed when the Institute was formed, were low; the trade subscription was £3 3s. per annum. If research were to be carried further it might be necessary in the near future to discuss methods of increasing the funds available, by means of increased subscriptions, donations or other methods.



SIR HAROLD HARTLEY.

The members of the Institute who had visited the United States had seen the very latest machines used for carrying out various tests, and the joint Research Committee had been considering the possibility of making such plant available to members, and particularly to the Research Officer. The Scottish Section of the Institute had raised that point. Of course, such plants were expensive, the total price of a set of them being in the neighbourhood of £2,000, and the problem as to how far the Institute could go in that direction would be considered in the near future.

Finance

MR. W. S. GRAINGER (Hon. Treasurer) presented the accounts for the year ended March 31, 1938, as certified by the accountants. The deficiency for the year was £50 2s. 8d., so that the surplus of £206 11s. 7d. for the previous year was reduced to £156 8s. 11d. The amounts due to creditors totalled £39 2s. 5d. Assets at bank and cash in hand totalled £174 3s. 9d., and the value of office furniture (less depreciation) was £21 8s. 7d.; so that total assets amounted to £195 12s. 4d.

Mr. Grainger gave details of the income and expenditure.

The CHAIRMAN commented that the accounts for the year included the payment of Secretary's remuneration over two years, and audit fees for two years; taking those factors into consideration, there was really a surplus of £40 odd rather than a deficit of £50 2s. 8d.

On the motion of MR. A. C. SMITH, seconded by MR. J. H. GRAY, the accounts were adopted.

Re-election of President

The CHAIRMAN, proposing the re-election of Sir Harold Hartley as President of the Institute for the ensuing year, said that, in view of the work which the Institute was doing, it was essential that its President should have great interest in research. Sir Harold had played a very great part in research work in various spheres for many years, and he had given the Institute very valuable help and support.

MR. W. S. GRAINGER, seconding, paid a tribute to the expeditious manner in which Sir Harold had conducted the business of the Institute. He pointed out that Sir Harold, who was connected with various research organisations, wanted the Institute to do something worth while, and therefore it was a pleasure to be able to second his re-election.

Sir Harold Hartley was unanimously re-elected, amid applause, and briefly expressed his appreciation of the honour.

Election of Members of Council

In connection with the ballot for the election of Members of Council, MR. C. P. STONE raised the question of the desirability of the inclusion on the Council of representatives of the suppliers of raw materials to vitreous enamellers. He referred to the rule which excluded them from the Council as being the Institute's "original sin," and urged that in present circumstances in the industry it was important that they should be included. In support of his contention, he said he had been told by an officer of the sister institute in America that that institute would have been dead years ago but for the support of the suppliers, and that they relied upon the frit suppliers for 90 per cent. of the Papers presented.

Mr. Stone said he had mentioned the matter earlier to one of the officers of the I.V.E. and had sent a cable with regard to the matter recently. His anxiety was that if there were no suppliers included among the list of candidates for election to the Council at that meeting, they could not be elected until next year. There were others who agreed that it had become desirable to include suppliers of materials on the Council of the Institute.

It was pointed out by the CHAIRMAN, however, without expressing any opinion on the merits of the rule which excluded suppliers, that the Institute must abide by its Articles of Association and the rule must be applied until it was altered by a meeting of which all members had had due notice. Before a motion on the matter could be discussed, due notice of that motion must be given, and if it were desired to expedite the matter, an extraordinary general meeting could be called, of which all members would receive notice.

The part to be taken by suppliers in research was another matter raised. In answer to questions, he said that the joint Research Committee, comprising representatives of the Institute and

of the British Cast Iron Research Association, had decided that any sub-committee formed would be a real technical sub-committee, and those who were best fitted to serve on it, whether they be suppliers or others, would be invited to do so.

MR. STONE pointed out that the policy of the Research Committee would be controlled by the Council indirectly, and therefore the policy of excluding suppliers from the Council was wrong.

It was pointed out by other speakers that one or two of the candidates for election to the Council could be regarded as being associated with the supply of raw materials.

The CHAIRMAN read the rule which governed the matter, as follows:—

"No member who or whose firm is engaged in or associated with the manufacture or supply of plant, apparatus or raw materials used in the vitreous enamelling industry shall be eligible to serve on the Council."

He emphasised that the rule was made by the members themselves, and it could only be altered by the members. Meanwhile, it must be applied.

The question then arose as to the interpretation of the rule, and a MEMBER wondered whether a vitreous enameller who held shares in a supply company could be held to be "associated" with the supply of materials, etc. Such an interpretation, he said, would be ridiculous. It would be a different matter if a man were a director of a supply company. The CHAIRMAN replied that the Council interpreted the rule in a sensible manner; if a man were concerned mainly with the supply of materials, he could not serve on the Council.

(It was decided to consider privately, at the conclusion of the annual general meeting, the question as to whether the necessary notice of motion should be given.)

Meanwhile, it was decided to ballot for the election of members to fill four vacancies on the Council. There were seven candidates, and it was pointed out by a member that if any members of Council were not strictly eligible, they could be asked to resign.

The ballot resulted in the election of the following:—

Mr. W. H. Whittle (W. H. Whittle, Limited, Eccles, Manchester).

Mr. B. B. Kent (Sterling Manufacturing Company, London).

Mr. H. H. Aston (John Harper & Company, Limited, Willenhall, Staffs).

Mr. J. Nichols (Hurst Hill Enamel Company, Deepfields, near Bilston).

The President's Remarks

SIR HAROLD HARTLEY, after having expressed his appreciation of the honour of his re-election as President, discussed the question of research. Inasmuch as the Institute had decided, at its last annual meeting, he said, to make a start with research, he had been interested to see what was being done abroad, and he had made one journey to Germany particularly to see what was being done in regard to vitreous enamelling there.

Commenting on the survey of the situation by Dr. Martin, the Research Officer, who had visited a great many works, he agreed that such a survey was necessary as a preliminary. The first thing to do was to take stock and to determine the matters which needed attention first; and in the making of that survey, Dr. Martin had had the opportunity of getting into touch with the work that was going on at the works. That was important, because Dr. Martin was not originally a vitreous enameller. Having had a lot to do with industrial research, the President emphasised that its value and its applicability depended very much on the research workers being in direct touch with the practical work in the industry and knowing the day-to-day difficulties and the long-term problems that were met.

With regard to research equipment, he said that those members who had visited America had seen a good deal of apparatus in use for testing, control and standardisation, and it had been suggested that it would be a good thing to have some such apparatus available at a central point, such as the Institute research laboratory, where the industry would have access to it. That, of course, raised a financial problem. During the last twenty years he had spent a good deal of time persuading people that it was worth while spending money on research, and he had to justify the expenditure on the research for which he was responsible; he had to show that the return on that research was a good deal greater than the amount of money spent on it. Provided one knew that the problems were worth attacking and that the work was being done by the right person, there was not the least doubt as to the value of that work.

Having looked through the Institute's "Proceedings," in order to see what the members were getting for their subscriptions, he was bound to say that in his view they were getting a remarkably good return. They paid only a small subscription; and the value of the meetings and the Papers presented, the facilities for bringing the members together, giving their industry a more corporate existence and enabling them to study their problems in a collective manner, must be very considerable. There was a very great difference between the subscriptions paid to the Institute and the subscriptions which he had had to persuade other people to make when they were going in for co-operative research. That was a problem which, it seemed to him, the Institute would have to face. Whether they considered it was of sufficient importance to the industry and of sufficient advantage to themselves and their firms that they should give further financial support depended upon their view of the competitive position and the advantages that would be derived from the work. It was necessary to be frank on that matter. He recalled that in the early days the British Cast Iron Research Association had needed financial help; that help had been given and the Association had pulled through; he did not think anyone would doubt to-day that it would have been a tragedy if that Association had been unable to continue its activities.

As a user of enamelled ware, he had a very considerable interest in the work of the industry, and it seemed to him that there was a great deal to be said for gathering into the research organisation all the interests that could be brought in. Although very often the actual cost of the enamelling represented only a small proportion of the total value of an enamelled article, the final value of that article was enormously dependent on the quality of the enamelling. There were people who perhaps would not qualify for membership of the Institute or the Council, but who were very much interested. Without the help of the British Cast Iron Research Association, the Institute could not have started research without putting up a good deal more money in the first instance. That was one interest with which the research would be linked. When in Germany he had been very much impressed, regarding the matter from the competitive point of view, by the work which was being done there. Work was being done on fundamental problems of vitreous enamelling, and the results must be of very great value to the industry. No doubt a certain amount of the information obtained in Germany reached this country, but he did not suppose that all of it reached us.

In expressing the hope that the Institute would face the financial problem, the President said he was convinced, from his experience, that research was the best insurance for an industry, and a necessary insurance, becoming more important each year, as the applications of science became greater and more rapid.

Lessons from America

MR. B. B. KENT, who had taken part in the recent visit to America, endorsed the President's remarks. The American trip, he said, was a great success. Those who had taken part in it had travelled between 2,000 and 2,500 miles by air, had visited nearly a dozen plants and had been considerably impressed by the amount of research in progress there. At three plants in particular, hundreds of thousands of dollars must have been spent on apparatus for checking purposes. Further, there seemed to be no secrecy about any of the processes; the frit makers and other firms seemed to be content to pool, and they published pamphlets indicating their collective findings. No doubt much of the apparatus which the President had seen in Berlin was identical with that which the members had seen in America, because quite an amount of that used in America was of German manufacture.

A number of questions were raised by members on various matters concerning the Institute.

MR. KENNETH HILL asked if the representatives of the Institute on the British Standards Committees had submitted reports as to progress.

The CHAIRMAN replied that reports had been submitted to the Council from time to time, but no definite reports had been published.

MR. A. ENGLAND, who pointed out that Dr. Martin, the Research Officer, had visited a number of works in the course of his survey, asked whether the Council had considered the possibility of competitors offering him a very large salary to leave the Institute and to utilise the results of his research on their behalf.

The CHAIRMAN replied that such risks had to be taken, but the Council had discussed the point very frankly with Dr. Martin, and had not lost sight of it.

MR. J. T. GRAY, discussing the future work of the Institute, said that whilst the application of science to industry was recognised by all as being of the greatest importance, it was well to consider whether the Institute was sufficiently large, or represented the industry sufficiently, to be able to undertake research extensively. He felt that the Institute's comparatively small resources might be utilised to better advantage if they were spent on the further education of the public in the use of vitreous enamel, leading to an increase in the number of vitreous enamelled products; further, vitreous enamellers who were still outside the Institute would then be more likely to come in, and the Institute would become strong enough to be able to increase subscriptions and to finance sound, solid research work.

The CHAIRMAN replied that the Council had given very serious thought to technical or commercial advertising; it had decided to spend some money commercially, and had approached enamelling firms and many others. But it was also felt that research would be of more benefit to the industry, and if it resulted in the improvement of finished enamelled products, that result in itself would be a valuable advertisement. However, Mr. Gray's comment would be noted; and members of the Council had spent a lot of time with the leading men in firms which were not in the Institute at the moment.

MR. STONE asked if it were considered that one or two men would be able to do the work on which 30 or 40 chemists were engaged in this country. The various suppliers had their own groups of chemists constantly at work; and apparatus such as had been seen in Germany and in America was in the hands of suppliers in this country, and not in the hands of a central body, such apparatus being required every day and all day long. The suppliers had spent a great deal of money on apparatus, in the interests of the customers they served. They had experience and practical knowledge, and it was hardly to be expected that any one man, however scientific, could carry out work of use to the industry as a whole if he had not practical knowledge.

THE CHAIRMAN replied that the work would not depend solely on Dr. Martin; he was the leader of the staff, and there would be pooling. He referred to the advantages which had been derived in the cast iron, rubber, gas, non-ferrous metals and refractories industries by co-operation in research; and if those mentioned by Mr. Stone would pool resources, benefit would result. The Institute had gone further, and the manufacturers on the Council of the Institute had been pretty well as open with each other as it was possible to be. They had considered whether or not they should appoint a practical enameller to take charge of the research, and had decided to appoint a man with a research mind, who could study the problems with an unbiased mind; and he was promised facilities for going through the plants of various manufacturers and suppliers.

MR. J. H. GRAY, emphasising the importance of apparatus for control, said that although he did not suggest that enamelling in America was better than in this country, it might become so in the future, by reason of the control that was exercised. He was concerned particularly with the problem from the point of view of setting up standards, because if other countries provided so much control and could set their standards, the enameller in Britain would be faced with a great deal of competition, from imported articles which might be better than could be produced here. We in this country should study methods by which we could set up standards.

MR. W. S. GRAINGER replied that the Committee had decided on a survey of all the physical tests available for enamels, and it was the intention to recommend to the sub-committee which would be formed the establishment of proper standards and tests. After expressing his appreciation of the contributions which had been made by the suppliers, he commented on Mr. Stone's remarks concerning the importance of practical knowledge in research, and said that generally the best approach was made by a scientifically trained and independent mind. There had been opportunities of appointing enamel works chemists, but it was decided to appoint a man who was trained in research, knowing that he would very easily assimilate any information given to him by the technical sub-committee.

The PRESIDENT, dealing with the references to the researches made by individual firms and the suggestion that a central body was unnecessary, pointed out that individual companies in the electrical industry, such as the Metropolitan-Vickers Company, the General Electric Company, and so on, spent a very great deal on research; yet that industry had one of the strongest research associations, because there were problems which could best be dealt with centrally, and could be dealt with most economically in that way, for the benefit of all. The fact that individual companies conducted research did not eliminate the advantage of the work in a central organisation, which they all shared.

Vote of Thanks to Mr. J. H. Coupe

At the conclusion of the meeting, the CHAIRMAN proposed a hearty vote of thanks to Mr. J. H. Coupe, who had retired from the Council, for the great amount of work he had done on behalf of the Institute since its inception.

The vote of thanks was accorded with enthusiasm.

MR. COUPE, in response, assured the meeting that he had derived the greatest possible pleasure from anything he had been able to do for the Institute. By reason of the fact that he was living in Wales, he found it impossible to be quite so active in the Institute's work as he had been formerly; but his interest in it was quite undiminished.

A Suggestion for Future Meetings

At the close of Saturday's technical session, MR. J. T. GRAY suggested, for the consideration of the Council, that at future conferences the annual general meeting of the Institute should be held on the Saturday instead of on the Friday afternoon, for there were always larger attendances on Saturdays than on Friday afternoons when the banquets were held on Friday evenings. An alternative was to hold the annual general meeting on the Friday afternoon for the transaction of formal business in the limited time available, and then to arrange an extraordinary general meeting on the Saturday to give members the opportunity to discuss matters of general interest concerning the Institute and the branches.

The CHAIRMAN assured Mr. Gray that the Council would consider his suggestion.

The Annual Banquet

There were many distinguished members and guests present, with their ladies, at the Institute's banquet, which was held on Friday evening, October 28, at the Hotel Normandie. They were received by the President (Sir Harold Hartley, C.B.E., M.C., F.R.S.) and Lady Hartley, and they included Sir David Milne-Watson, Bart., LL.D., D.L. (President of the British Gas Federation, and Governor of the Gas Light & Coke Company), Sir William Larke, K.B.E. (Director, British Iron and Steel Federation), Lieut.-General Sir Hugh Elles, Prof. Egerton (Imperial College of Science and Technology), Mr. J. W. Fagan (President of the Ceramic Society), Mr. Coutts Trotter, Mr. J. G. Pearce (Director and Secretary, British Cast Iron Research Association), Mr. J. E. Hurst, and Mr. V. C. Faulkner (Past-Presidents, Institute of British Foundrymen), Dr. G. T. O. Martin (The Institute's Research Officer), Mr. Barrington Hooper, C.B.E., Mr. W. H. Whittle (Chairman of Council), and Mr. J. W. Gardom. Most of these guests were accompanied by their ladies.

SCENE AT THE ANNUAL BANQUET OF THE INSTITUTE AT THE HOTEL NORMANDIE.

The Toasts

The loyal toast having been honoured, SIR DAVID MILNE-WATSON, Bart., LL.D., D.L., proposed "The Institute of Vitreous Enamellers and the Vitreous Enamelling Industry." In the first place, he welcomed the foundation of the Institute, the purpose of which was to help the development of the industry and the achievement of even better results than had been achieved so far; and he pointed out that the art of vitreous enamelling was very ancient, and had done a great deal of service in the world. Beauty of appearance, he said, was undoubtedly most important; for example, the attractiveness of the peach, the pear, the plum and the apple was enhanced enormously by the bloom on them. That attractive appearance of fruit had been provided by nature, and the vitreous enamellers were trying to do the same with the baser metals!

Perhaps it had never occurred to the members of the Institute, continued Sir David, that there was a close resemblance between vitreous enamelling and cosmetics, in that they were "putting a good face on things" (laughter). They rendered the utilitarian object decorative—if one were permitted to refer to ladies' faces as utilitarian! The vitreous enamellers were the Elizabeth Ardens of the industrial world! But the resemblance did not end there, for both vitreous enamelling and the application of cosmetics were processes of great delicacy and complexity, and the execution of those processes occupied a long time. To use the language of industry, enamelling was not a substitute for proper cleansing; whether the object be metallic or human, de-greasing before enamelling was important!

He understood there were often disputes between the makers of iron and the vitreous enamellers, that when the work was not satisfactory the enamellers often blamed the products of the iron foundry. (Cries of "No."). He believed also that sometimes a beauty specialist blamed the original complexions to which he endeavoured to give a false bloom!

Then there was a further resemblance between the vitreous enamellers and those who applied cosmetics. He gathered that a lady in full war paint felt stronger and better able to tackle the world; she was able to tackle hard-faced business men and obtain orders from them better when she was "got up" than when she was not "got up." Similarly, iron was better able to tackle the world when decorated with enamel than when not so decorated!

Decorative Gas Cookers

Striking a more serious note, Sir David acknowledged that the gas industry owed a great deal to enamelling. The old black gas cooker, he said, had cooked very well; but it became out-of-date, it was not comely and it was discredited. Then the enamelling of those cookers had enabled the gas industry to hold its own with the latest devices of its rival industries, and it owed a great debt of gratitude, therefore, to the vitreous enamelling industry. Millions of gas cookers, fires and other apparatus were enamelled, and they had given the greatest satisfaction not only in Mayfair, but also in West Ham. In any case, he wished to thank the vitreous enamelling industry for what it had done, for it had really brought the gas industry along in a way that one would hardly have believed to be possible. One had only to contrast the good old cast-iron cookers and fires with those available to-day to be able to appreciate what a great improvement had been effected by enamelling. It was a very great pleasure to him, therefore, to have been invited to enjoy the Institute's excellent hospitality, and to be able to say, as an industrialist, how much he appreciated the good work the vitreous enamellers were doing for the industry in which he was interested; and he was perfectly certain that other industries would say "Amen" to his remarks about the good work of the vitreous enamellers.

In a tribute to Sir Harold Hartley, whose name he coupled with the toast, Sir David said the Institute was fortunate in having a man so distinguished to serve as its President. Sir Harold was not only a great scientist, but also a great industrialist, and must be of immense service to the Institute in its work. (Hear, hear.) It had been of great interest to watch his rise from academic spheres to the industrial world, and he occupied a place almost unique in the industry of this country.

In conclusion, Sir David thanked the Institute for its hospitality, and wished it success in its future work, which was of the greatest importance to industry.

Research Activities

The PRESIDENT, in his response, said it was an honour and a very great pleasure to him to be able to preside again at the annual banquet of the Institute, where the members were able to meet together, to entertain friends and to enjoy their company. No one could more appropriately have proposed the toast to the industry and to the Institute than Sir David Milne-Watson, because the link between the gas and the vitreous enamelling industries was so very close. When Sir David had said that the gas industry owed much to the beautiful finish of enamelled appliances, one could not help remembering how much the gas industry owed to Sir David for his far-sighted encouragement of the scientific development of that industry, to which it owed the place it occupied to-day. (Hear, hear.)

After a tribute to Mr. Whittle (chairman of Council), who was the leader of the Institute's activities, and by whose kindness he (Sir Harold) was presiding, Sir Harold said that he would not have been elected to the presidency of the Institute had not Sir David taken the very great risk of suggesting, some years ago, that he should leave a university and try his hand in industry.

It was very proper, continued the President, that the toasts to the industry and to the Institute should be linked together, for the Institute was the means of bringing members of the industry together, and one had only to look around the tables to be able to appreciate how effectively the Institute was doing that job. He had been provided with a number of statistics; but the company provided much more convincing proof of the prosperity and well-being of the industry than did any statistics that he could give. It had been said by Lord Stowell that "a good dinner lubricates business"; but in the presence of Sir David, the chairman of the Anti Bribery and Corruption League, that was not quite a proper sentiment to express! (Laughter.) Being a good Scot, he would remind Sir David of the proverb, "Better is a dinner of herbs, where love is, than a stalled ox and hatred therewith." Those present at the banquet would agree that they had the best of both worlds on that occasion.

In welcoming home the members of the Institute who had visited America recently, headed by Mr. B. B. Kent, the President said that, having been to America himself, he appreciated how much there was to see and learn and enjoy there. It was very important that we should have good ambassadors in America, and we could not have had better ambassadors than Mr. Kent and the other members of the Institute who had accompanied him. (Hear, hear.)

It was also a very great pleasure to welcome Mr. J. G. Pearce (director of the British Cast Iron Research Association) and Dr. G. T. O. Martin (the Institute's Research Officer), because this year the Institute was making its first adventure into research. He defined research as "finding out what we can do to-morrow if we cannot go on doing what we are doing to-day," and said that without that forecast of the future we might find ourselves in difficulties. At the Institute's annual meeting in 1937 he had said that research was the best insurance policy for the future of an industry; the Prime Minister had done him the honour of quoting that only two days afterwards, and had added: "It has this additional advantage, that the results of research generally spread far beyond the original objective and are nearly always found to open up new and profitable fields of inquiry." It was quite certain that the Institute's new adventure would add greatly to its strength.

Finally, the President thanked Sir David for his charming speech, and voiced the pleasure of the members of the Institute in being honoured by his presence; and he thanked the company for the enthusiastic manner in which the toast had been received.

MR. J. W. GARDOM, proposing "The Guests," jocularly expressed his gratification in the fact that for the first time his colleagues on the Council had allowed him to speak at a function attended by ladies. It had been hinted, he said, that his vocabulary was too extensive; and, admittedly, he had to spend a good deal of time in the foundry, where the language was definitely different from that used in other places!

Of the many guests present, he mentioned first the ladies, and set out to discredit the suggestion often made by speakers who welcomed the ladies that one reason for inviting them to attend such a function—apart from the prime reason that their presence was so pleasurable—was to repay them for having allowed their menfolk to attend meetings during the year. Such a suggestion, he said, was ridiculous. If there were one quality which the ladies possessed in greater degree than men, it was common sense, and they appreciated at once the advantages which the men derived from their attendance at technical discussions! No doubt they had noticed that the men returned home filled with a spirit which enabled them to see two or three ways of getting over any problem! At any rate, the Institute extended a very hearty welcome to the ladies, as to all the other guests present.

In a tribute to Sir David Milne-Watson, Mr. Gardom referred to his great encouragement of research, and to a recent statement by Sir David that his company spent £100,000 a year on research. As compared with the amount spent by the Institute—a body which had been in existence for only five years—that might appear to be a very big sum; but, at any rate, the Institute was spending on research 70 per cent. of the money it could possibly earn, and that was a real effort.

It was a privilege to sit at the same table as Lieut.-General Sir Hugh Elles, not only because he was the representative of the Government on the Sugar Council, and therefore was very sweet, but also by reason of his great services during the war.

Other guests who were mentioned particularly were Prof. Egerton, whose work in connection with fuel and combustion at the Imperial College was of great value and of great interest to the vitreous enamelling industry; Mr. J. G. Pearce (Director and Secretary of the British Cast Iron Research Association); Dr. Martin (the Institute's Research Officer); Mr. J. E. Hurst (a Past-President of the Institute of Foundrymen, and a man who had contributed enormously to the development of cast iron); Mr. Fagan (President of the Ceramic Society); and Sir William Larke, whose name he coupled with the toast. Sir William, he said, was indeed a friend to all Institutes, and one could not recall any occasion on which he had failed the harassed secretary of any institute who had asked for his help. Apart from that, he had done great work for industry, and recently he had been concerned with the selling of tinplates for the purpose of canning foodstuffs. Perhaps one might suggest that he would be able to sell still more tinplates if the "food" were put into them at Burton! He also handed to Sir William some enamelled ash-trays, and suggested that if steel sheet could be made equally attractive the sales would increase enormously.

Finally, Mr. Gardom added a word for absent friends, and he paid a tribute to Mr. Todd, whose work was almost the foundation of the Institute's progress and who was extremely keen to further its aims. It was a matter of great regret to Mr. Todd that he was unable to be present, a regret which was shared equally by his many friends. (Hear, hear!)

SIR WILLIAM LARKE, K.B.E. (Director, British Iron and Steel Federation), responded to the toast, at any rate, on behalf of the male guests; so far as the ladies were concerned, he preferred to join in returning thanks to them for their presence. It was unfortunate, he added, that our English tradition of taking our pleasures sadly precluded the presence of ladies at meetings which the President and himself had to attend from time to time.

Commenting jocularly on the remarks of Sir David Milne-Watson, he suggested that he had done the vitreous enamellers less than justice by his remark that if they experienced troubles they blamed the defects of the iron to which the enamel was applied. As a representative of iron, Sir William denied that there were ever any defects in it; but, even if there were, he would not think much of the vitreous enamellers' "beauty parlour" if they could not cover up those defects. Indeed, was not that the whole reason for their existence? However, he held a much higher opinion of the vitreous-enamelling industry than to believe that it blamed the iron when there were defects in the enamel; to do so would be to confess their own ineptitude.

On behalf of the guests, Sir William returned thanks to the hosts for their bounteous hospitality and charming entertainment, and, above all, for that supreme gift of hospitality—good company.

The speeches concluded at an early hour, and plenty of time remained for dancing.

Scientific Aids to Control in Vitreous Enamelling

By J. G. PEARCE, M.Sc., and G. T. O. MARTIN, Ph.D.

(Presented at The Institute of Vitreous Enamellers' Annual Conference last Saturday)

Introduction

The rapidly increasing popularity of vitreous enamel finishes has created a demand for methods of testing and control which can be systematically applied to raw materials, to the process at appropriate points during production, and to the finished product. Such methods give quantitative standards of performance, as opposed to the qualitative results of examinations by individuals, the results of which, however much they are aided by experience, lack the precision of scientific measurements, and which vary from person to person because they must depend to some extent on personal factors. Scientific control enables standards to be settled by the management. The increasing literature on the subject indicates that definite progress has been made in some of these directions in the United States of America, and a recent visit to that country has confirmed this.

In general, it is probable that more sheet iron and steel is enamelled in the United States than cast iron, while in the United Kingdom the reverse is the case. The climatic conditions, the comparatively high standard of living, and the standardisation of quantity-produced products have resulted in a very large throughput in the U.S.A. of a variety of products, many of which are enamelled. This has stimulated the demand for scientific aids to control in production. This demand has largely been met by the efforts of the large frit-making companies, all of which maintain laboratories and research departments for the purpose of dealing with the difficulties of their clients and for promoting advances in the art. Good work has also been done at the Bureau of Standards, both independently and on the initiative of the Porcelain Enamel Institute.

Control methods in vitreous enamelling can be divided into three classes, dealing with (1) the raw materials of the process; (2) the enamelling process itself, and (3) the finished product. It would be impossible to cover all these sections adequately in one Paper. This Paper will, therefore, be confined chiefly to the third section, that is, the testing of the finished enamel surface.

Under "control of the raw materials" can be considered chemical analysis of the ingredients, of the enamel batch, and control of the production and preparation of castings and stamped or pressed steel shapes. All these fall outside the scope of this Paper.

Process Control

Control of the enamelling process itself is already practised to a considerable extent in this country. For wet-process enamelling a number of so-called "shop tests" are in use, and frit makers usually recommend certain tests to firms using their frit. It is notable that frit manufacturers are among the foremost advocates of control methods in vitreous enamelling, since they realise that the careful control exercised in the frit manufacture would otherwise be largely wasted.

The tests to which reference is made are fineness, density and viscosity of enamel slip, groundcoat dipping weight control, spray weight control, and firing trials on small test-pieces. Larger firms can naturally afford to undertake more extensive process control than smaller ones. Actually, there is more need for control methods in a large enamelling shop, since the enamelling expert cannot give the personal supervision that is possible in a small shop. Unfortunately, the interest taken by many enamellers in control methods tends to decline when no troubles are being experienced, and it is not always realised that "prevention is better than cure" should be a fundamental working principle in vitreous enamelling.

In general, various works measure the same properties of the enamel, but there are differences in the way in which the tests are carried out. From visits to firms in this country, it was found that a standardisation of testing methods would be quite acceptable to the industry. Much valuable information was obtained from firms who demonstrated and discussed their testing methods. From experimental work on the comparison and possible improvement of these methods, it should be possible to develop standard tests suitable for both works and laboratory use.

Dry-process enamelling naturally has its troubles and difficulties, but is simpler than wet-process enamelling and involves fewer operations There are thus fewer points where trouble can occur. Also it depends to a very large extent on the skill of the worker, and little can be done besides testing the frit and seeing that, especially for coloured enamels, it is properly ground. Many of the testing methods to be described in this Paper are, however, equally applicable to wet-process or dry-process enamelled surfaces.

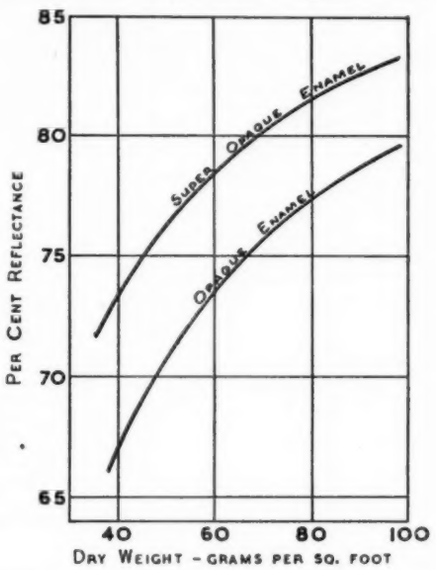


FIG. 1.—REFLECTANCE-THICKNESS CURVES.

Control of Finished Surface

The apparatus and methods which have been developed for testing enamel surfaces are briefly described below, classified under physical, mechanical and chemical methods. The apparatus involved is in some cases expensive, but of its utility and value there can be no doubt, and there is ample justification for the provision of such apparatus in at least one centre in this country to which practising enamellers have access. It is not suggested that all vitreous enamellers in the United States are equipped with the apparatus mentioned, although this is true of some, either wholly or in part, but all the users of frit made by the above-mentioned companies have access to such apparatus through their suppliers. Broadly speaking, the manufacturers in the United States who make their own frit are makers of enamelled grey-iron castings, chiefly sanitary ware and kitchen utensils, and many of these use leaded enamels. They doubtless also use similar apparatus. Neither is it suggested that these tests are applied as a routine control. For much of the apparatus, the reverse is the case. From the knowledge gained by use of these tests, it becomes possible to enamel with a minimum of testing in the enamelling shop itself.

The apparatus described below is grouped according to whether the basis is physical, mechanical or chemical. The physical tests include tests for reflectance, for thermal expansion and for colour matching. Mechanical tests include transverse and drop tests for adherence and the thickness measuring gauge. The chemical tests include acid-resistance. Where prices are quoted, it must be understood that they are not taken from formal quotations, but are list prices, given merely to convey some idea of the order of magnitude. They are not necessarily ruling at the present time and take no account of import duty and freight charges. While the apparatus is mainly that developed in U.S.A., reference is also made to related work which has been carried out in this country and in Germany.

PHYSICAL TESTS

Reflectance and Gloss

Of recent years, great improvements have been made in the light-reflecting powers of white vitreous enamels, and modern opaque or super-opaque frits, together with suitable mill additions in most cases, give a surface of much greater "whiteness" than was obtainable some years ago. Due to the improvement in the "hiding power" or opacity of these enamels, it is possible to use a thinner coating. This gives a more durable product, less liable to damage by hard use. This property of opacity of vitreous enamel has been the subject of a great deal of scientific research in the United States, and the measurement of the reflectance, *i.e.*, the percentage of light diffusely reflected, has become almost universal on sheet metal enamels.

It would be interesting to have opinions as to what optical properties of enamelled surfaces are regarded as essential for an enamelled article to be of good commercial quality. Apart from colour, two optical properties are now considered essential for the specification of an enamelled surface. These are (1) the reflectance, or diffuse reflection of light and (2) the gloss, of which two aspects can be considered, (*a*) objective gloss or "shininess" due to direct (*i.e.*, specular) reflection from the surface of the enamel coating and (*b*) the subjective gloss, or the extent to which a sharp reflection image of an object is produced. An investigation of the optical properties of what are regarded as "good" commercial vitreous enamels would be of great value. It could lead to the establishment of quality standards, which would tend to bring about an all-round improvement in the quality of enamel finishes. Good as the present-day enamels may be, continual improvement is necessary to compete with other finishes and to find new applications for vitreous enamel. While the comparison of British and American enamelled articles is best left to those who have had American experience, it will be agreed by everyone that the United States enamelling industry has benefited considerably by the use of quantitative figures to express the properties of enamelled surfaces. The importance attached to this can be judged by the fact that the Porcelain Enamel Institute has been working in close co-operation with the Bureau of Standards for a number of years and has issued various specifications.

Dealing first with the opacity of enamels, it should be remembered that this property is due

to the presence in the enamel glass of small particles of a refractive index different from that of the glass. These particles may be of a higher refractive index than the glass, *e.g.*, tin oxide, antimony pentoxide, or of a lower refractive index, *e.g.*, gas bubbles. Diffusion of the incident light is produced by reflection, refraction and diffraction by these particles.

It has been found that by increasing the thickness of a white enamel layer over a dark background, the reflectance, or amount of light diffusely reflected, at first increases rapidly. The rate of increase continually decreases, however, until a thickness is reached where no further increase of reflecting power occurs. This value is known as the reflectivity of the enamel and is referred to below. Fig. 1 shows the increase of reflectance with enamel thickness, leading to a maximum of about 80 per cent. for a normal, and over 83 per cent. for a super-opaque enamel.[1]

The Porcelain Enamel Institute[2] has adopted standard tests for reflectance, and specifications for enamel frits and enamelled surfaces. The reflectance test for individual specimens determines what fraction of light incident on the specimen is diffusely reflected, specular or direct reflection being ignored. To predict the reflectance of a coating of any weight of any given batch of enamel, the enamel is characterised by two constants. The reflectivity (R) is the reflectance of a coating so thick that increased thickness does not increase the reflectance (*i.e.*, the maximum referred to in Fig. 1). The coefficient of scatter (S) is the rate of increase of reflectance of the enamel coating with increasing thickness (expressed as weight per unit area) at infinitesimal thickness over a black backing. These two constants are determined by measuring the reflectance of layers of differing thickness and of very great thickness. The value of S is the mean of values obtained for each thickness from a graph derived from a mathematical relationship worked out by Kubelka and Munk. For the commercial classification of enamel frits into clear, opaque and super-opaque, the reflectance at a specified thickness of layer is used.

Reflectometers

Many different types of reflectometer have been devised for measuring the reflectance of a given sample, but only a few have found practical application. For some purposes an "absolute" reflectometer may be required, but for normal work an instrument that will compare specimens with a standard is sufficient. Magnesium oxide is usually used as standard, being assumed to have a reflectance of 97 or 98 per cent. For regular use, more durable and permanent standards of vitreous enamel or opal glass are used, with known relationship to magnesium oxide.

In the United States, the Hunter and Priest-Lange reflectometers are the best-known types. The Hunter reflectometer is the one commonly used, on account of its simplicity of construction and operation. In the original type, the light reflected diffusely from a normally (90 deg.) illuminated test piece is compared with that reflected from a standard by viewing at 45 deg. The two surfaces to be compared are illuminated by opposite sides of the same lamp, and by movement of the lamp between them, the illumination on each is so adjusted that the light reflected from each is the same. The position of the lamp is then read on a scale which is calibrated to read directly in per cent. reflectivity. The comparison of the light reflected from the two surfaces is achieved by means of a pattern mirror photometer head, which is viewed from outside the casing of the reflectometer. One surface is seen reflected in the mirror and, directly in contact with it, the other surface is seen through the pattern where the mirror metal has been removed. The lamp is then adjusted until both parts of the field of view appear equally illuminated.

In a later type of Hunter reflectometer, this type of photometer was replaced by a pair of matched photo-electric cells, one receiving light from the test surface and the other light from the standard. These cells were connected in circuit with a galvanometer so that the reading of the latter was zero when each cell was equally illuminated.

Gloss

In the above measurement of reflectance, the effect of the gloss has not been considered. This is quite justified when dealing with enamels all having similar gloss, but it would be unfair to compare high- and low-gloss enamels in this way, since the light reflected directly from the former would leave less light to be diffusely reflected and the glossy surface would appear to have less reflectance than the matt one.

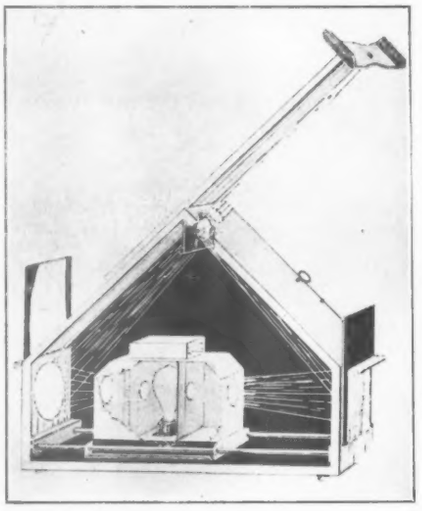


FIG. 2.—HUNTER REFLECTOMETER.

For the determination of objective gloss or "shininess" a similar type of instrument has been devised, in which the amounts of light reflected directly from the two surfaces are compared by a pattern mirror photometer head, as used for reflectivity measurements. By means of this Hunter "Glossmeter" specular reflection can be measured and expressed numerically.

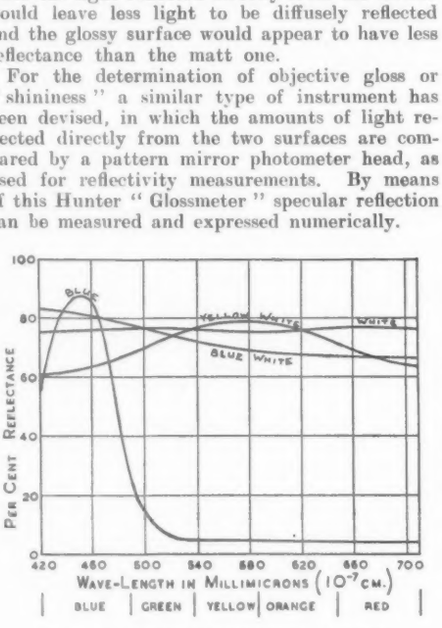


FIG. 3.—SPECTROPHOTOMETER CURVES.

For the estimation of subjective or "sharpness of image" gloss a "target" consisting of light and dark rings of various widths is viewed by reflection in the gloss surface. Different types of surface give different kinds of image, the sharpness of the light and dark bands being destroyed to a greater or less extent. In the Hunter Gloss Comparator, the surface to be tested is compared with that of a standard glass plate. The image produced by the standard plate can be diffused by adjustment of a ground-glass plate until the amounts of distortion of the two images are the same. The position of the diffusing plate gives the numerical value of the subjective gloss on a scale. This instrument is also equipped with a camera, so that photographic records of the images can be kept.

For the gloss of paint surfaces, it is considered in this country that subjective gloss measurement is the only practicable method of specification, as the objective gloss depends on the colour of the surface coating.

A multi-purpose Hunter reflectometer has now been developed, by which all these properties can be measured, together with the determination of colour and colour differences. The principle of operation is similar to that described above, using photo-electric cells. This type of reflectometer has not yet been placed on the market, but the provisional price is $250, with $43 for suitable colour filters, $60-$80 for galvanometer, and $20 for photo-electric cells. The simpler, original type illustrated in Fig. 2 is, of course, cheaper.

Colour Matching

The use of coloured enamels seems to be increasing, and the necessity for securing particular colours and for matching colours is becoming more important. It is coming to be realised that actual measurement of colour is the only way of obtaining a desired colour, or of matching two colours closely enough to satisfy the eye.

When discussing colour measurement, it is necessary to bear in mind one or two fundamental facts about colour; first that daylight or white light contains all the colours of the visible spectrum; second that a coloured object appears coloured because it absorbs all light rays except those of its own colour, which are then reflected or transmitted, according to whether the object is opaque or transparent. One colour perfectly matches another when both contain the same proportions of the constituent spectrum colours of which they are composed.

Considering opaque objects, such as vitreous enamelled surfaces, it will be seen that a knowledge of the amount of light reflected at the different parts of the spectrum will define the colour. Such values can be plotted on a curve,[3] Fig. 3, which shows for blue and several whites, the contribution to the total colour from each part of the spectrum.

A simple method of determining the amount of light reflected at different parts of the spectrum is by the use of a reflectometer, the sample being compared with the standard at different wavelengths by the use of colour filters in the eye piece. This gives the effect of viewing by light of different colours. There are two disadvantages attached to this method. The first is that it is difficult to obtain filters that transmit only monochromatic light, for usually a band of wavelengths is transmitted, instead of the single wavelength desired. The second is that in order to cover the whole range of wavelengths, a large number of filters would be necessary, if the curve is to be of reasonable accuracy.

A better method of colour analysis is the use of a spectrophotometer. In its simplest form, this instrument uses a prism to analyse the light reflected from the sample and from a standard (usually magnesium oxide or carbonate), the intensities of the light reflected by the two surfaces being compared at the different wavelengths. The comparison is achieved by reducing the intensity of the light reflected from the standard by means of a calibrated rotary filter, which gives a reading in per cent. light reflected by the sample. The wavelength is recorded by a scale actuated by rotating the prism to alter the wavelength. This type of instrument costs about $850 to $900.

A further development of this type of apparatus is the use of a photo-electric cell, which is more reliable than the human eye. The most advanced type of spectrophotometer is the

General Electric recording type shown in Fig. 4. In this instrument (which is priced at $4,900) the difference in the reflecting properties of sample and standard is made to operate a recording mechanism, and the instrument automatically plots a curve connecting wavelength with percentage reflectance.

The spectrophotometer can distinguish easily between two colours which are so alike as to be only distinguishable with difficulty by the eye. It enables exact colour matching to be done without errors due to different types of illumination and different observers. It is possible to specify colours exactly, and to analyse a colour to determine its components, so that matching is greatly simplified. While the instrument cannot of itself produce matched colours, it furnishes such information about the colours that matching is enormously simplified and taken out of the region of trial and error.

Thickness

Another test now commonly used in the United States is the measurement of the thickness of the enamel layer by means of the G.E.C. thickness gauge (Fig. 5). Measurements are made simply by holding the gauge head against the enamel surface, when the thickness can be read from the instrument in the indicating unit. It is only necessary to have access to the enamelled side of the sheet, and the enamel surface is not damaged in any way. The instrument operates directly from the electric mains and is adjustable for use on sheets of different thicknesses. The gauge head weighs less than half a pound and can be used on an area a little over one inch in diameter.

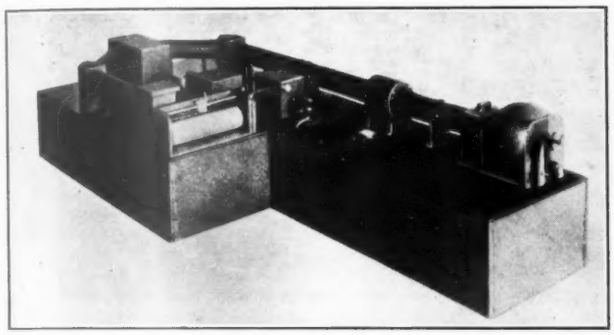


Fig. 4.—Recording Spectrophotometer.

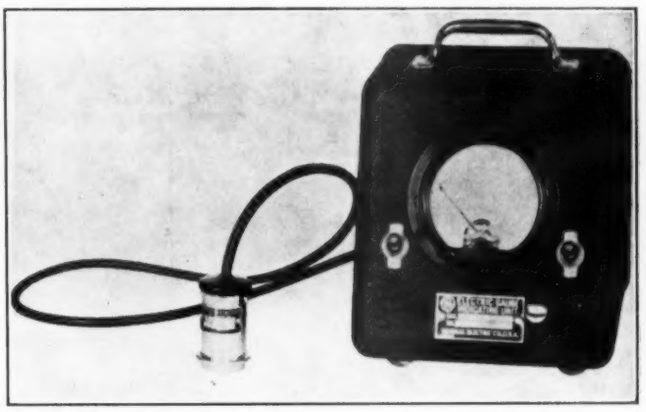


Fig. 5.—Thickness Gauge.

This instrument has been tested in this country, but does not appear to be in regular use in any works. Perhaps control methods in the industry in this country have not yet reached the stage where regular checking of enamel thickness is practicable. While the instrument cannot aid directly in producing uniformly thin deposits, it can provide the data as to the variations that occur, making further progress possible. The use of such an instrument at the inspection stage would avoid the chipping in service due to too thick an enamel layer, and parts on which too many cover coats have been applied could be rejected.

Thermal Expansion

A knowledge of the thermal expansion of an enamel is generally regarded as essential if satisfactory "matching" with the base metal is to be obtained. The normal method of obtaining the coefficient of expansion appears to be by calculation, using factors for the various oxides which make up the melted composition.

An objection that is frequently raised to expansion measurements is that the coefficient of expansion of the final enamel layer is not the same as that of the frit, due to the effect of mill additions, bubbles in the enamel and dissolved iron oxide from the metal; alternatively, it is argued that actual measurements on an enamel do not give the same results as enamel on its metallic base. Thus, it is said, calculation of the expansion coefficient gives just as reliable a result as experimental measurement. Of all the factors which influence the expansion of the final enamel layer, however, the frit is by far the greatest and most constant. Also, in dry-process enamelling, there may be no mill additions, and by micro-examination it has been found that a layer of dry-process enamel is very dense and free from bubbles. A ring method has been used to determine enamel expansion on a steel base.

The Interferometer

The best way of obtaining the expansion coefficient is undoubtedly by experimental determination. The interferometer method gives the most accurate results, but it is essentially a laboratory method, involving delicate work with very expensive apparatus. It is used in the United States in the development of new frit compositions. The following is a brief description of its principle of operation. From the material whose expansion coefficient is being measured, three small cones are made, about 0.5 cm. and of as nearly the same height as possible. These cones are used to separate the two interferometer plates. This assembly is slowly heated up in an electric furnace and the expansion of the cones increases the separation of the plates. The cones are arranged so that the plates are very slightly out of the true parallel position, and by interference of light waves reflected from the bottom of the upper plate, and the top of the lower one, a series of interference fringes is produced, which can be observed from above by a special viewing apparatus. As the test cones expand on heating, the fringes move across the field of view, and for each fringe passing a reference mark the cones have expanded through a distance equal to half the wavelength of the light used. Normally green light is used, with a wavelength of about 1/50,000 in. This gives some idea of the sensitivity of the method. It is so sensitive that it is customary to correct the results for the change of wavelength of the light with temperature. A correction is also made for any difference of temperature between the cones and the thermocouple used for temperature measurement, due to the fact that they are not in exactly the same position during the experiment. The price of the complete equipment is just over $1,000 but this could be reduced by making some of the parts in this country. Fig. 6 shows examples of the expansion curves obtained from such measurements.

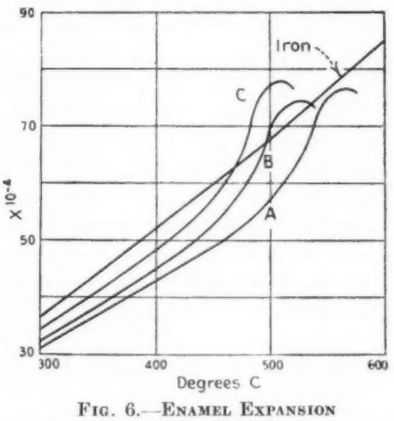


Fig. 6.—Enamel Expansion Curves.

Thermal Shock

One other physical test can be mentioned, although it needs no special apparatus. This is the thermal shock test, which is important for enamels to be used on heating and cooking appliances, and on cooking vessels. Various forms of this test are in use, but the principle usually consists of heating to 300 deg. C. or more, and cooling suddenly either by dropping water on to the surface, or plunging the object or test piece into water. A good enamel should show no crazing after this test.

A test partaking in a measure of a shock test and in a measure of an adherence test, is used in one U.S. laboratory. A standard small cast plate, enamelled on the upper surface, is put on a tripod and a bunsen burner is placed underneath, so that the cone of the flame just impinges on the underside of the plate. A thermocouple is placed on the upper surface covered with a sil-o-cel block. The temperatures are recorded when audible crazing occurs, when craze lines are visible and when blistering begins.

Microscopic Examination

The microscope finds increasing use in various tests of vitreous enamels, and for examinations of materials giving trouble in enamelling. When it is necessary to mount specimens, a synthetic resin mount is used, sometimes transparent, moulded and finished in a small hydraulic press.

MECHANICAL TESTS

Mechanical tests are applied mostly to a coating of enamel on a metal base, usually sheet metal. Properties examined in these tests are adherence of the enamel to the metal, hardness of surface and resistance to abrasion.

Adherence

The simplest type of test for adherence is to bend a sample of enamelled sheet through an angle of 90 to 180 deg. and examine the appearance of the enamel layer on the outside of the bend. A clean metallic surface indicates poor bond, but adhering pieces of enamel show that the bond is good.

Cross Bend

The Danielson-Lindemann deflection or cross-bend test was adopted by the American Ceramic Society as a tentative method of determining the resistance of sheet iron enamel to deflection. Standard test-pieces are placed in the deflection machine and bent gradually through definite angles at regular intervals. The ends of the strips press upwards against rollers, the centre being deflected upwards by a roller moved by a cam. The angle of rotation of the cam is recorded by a pointer on a dial, and deflection is continued until cracking of the enamel occurs. Fig. 7 shows the machine, but it is now very little used.

The result of the test depends on several factors. For instance, an enamel with lower expansion coefficient is under greater compression and can withstand more bending before the tensile strength is exceeded. McIntyre, Irwin and Ammon[4] made a detailed investigation of this method, using various sizes of test-piece. Greater variation of results was obtained with small test-pieces and a 4-in. × 12-in. piece is recommended. With this size, reflectance and impact tests can also be carried out on the same test-piece.

Ball Test

An apparatus for testing the adherence of ground coat to sheet metal has been described by Kinzie and Miller.[5] A steel ball is pressed on to the enamelled sheet, which is clamped between two thick metal plates, the pressure being applied slowly and uniformly until a certain deformation is reached. Flaking-off of the enamel, leaving bright metal, shows poor adherence, while with increasing adherence, more enamel remains adhering to the metal and the deformed area has a dark outer rim. This test resembles the cross-bend test in principle, and possesses the advantage that the properties of the cover coat enamel do not constitute the deciding factor, but it is not easily adaptable to quantitative estimation.

Impact Strength

Several forms of impact test have been used to examine the adherence of enamel to the base metal. Of these the simplest is the dropping ball test, which has been used in both America and Germany. A steel ball or cylinder is allowed to fall through a vertical tube or between vertical guides on to the specimen to be tested. The test is continued until failure occurs. The result is expressed as the number of blows from a given height, on to the same spot, required to cause failure, or the height from which the ball must be dropped once to cause failure of the enamel surface. One form of this apparatus is shown in Fig. 8.

In some forms of this instrument, the impact from a falling weight is transmitted to the enamel surface by means of a hammer or plunger fitted with a very hard ball tip, which is in contact with the enamel surface before the blow is struck. The test-piece usually rests flat on a bedplate, but in other versions of the test is supported over a hollow space, a certain amount of bending thus being permissible. In another case the test-piece is supported by a thick layer of sand.

The other form of impact testing machine that has been described in the literature is the swinging hammer type, *e.g.*, by Türk[6] and Holscher.[7] The variation in impact is obtained by alteration of the angle through which the arm is allowed to fall. By the use of hammers of different weights, a considerable range of impact values can be obtained and the position of the arm when released records the force of the blow in inch-pounds or foot-pounds on a scale. In both the above types of sheet test, pieces were supported so that flexing of the metal could occur, in imitation of service conditions. Holscher[7] distinguished three distinct types of impact failure for enamelled sheet metals: "(*a*) failure on heavy steel, which is primarily crushing failure; (*b*) failure on very light steel, in which no chipping or crushing is noted, and where failure is due only to bending of the steel and subsequent cracking of the enamel; and (*c*) failure characterised by chipping on medium thickness metal." Enamel on cast iron would come in class (*a*), but distinction must be made between the method of failure of direct cast iron enamel and that of enamel applied over a sintered ground coat. This type of machine does not appear to be used to any great extent in the United States.

Both the dropping weight and swinging hammer types of impact machine are suitable

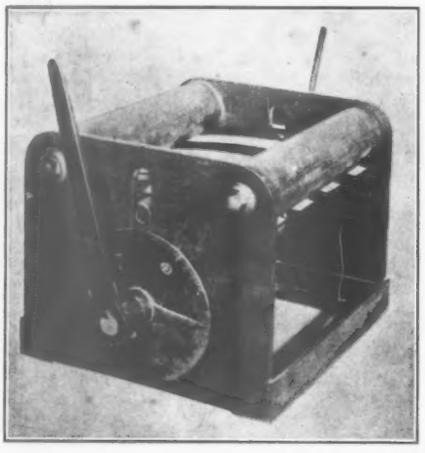


FIG. 7.—CROSS BEND TESTING MACHINE.

for use on cast or sheet iron enamels. Most of the published work describes experiments with small test-pieces, such tests being regarded as tests of the enamel. There is scope, however, for the use of such tests on the finished enamelled ware, thereby also keeping a check on the enamelling process. By regular testing of pieces picked at random from the output of the enamelling shop, any faults are revealed immediately, in-

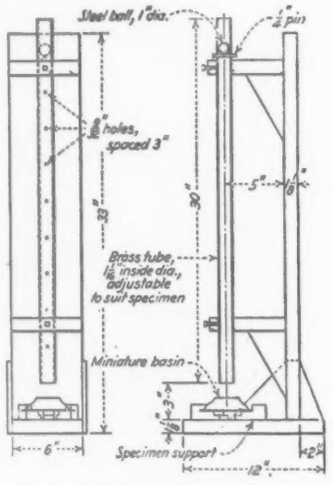


FIG. 8.—IMPACT TEST DEVICE.

stead of appearing during use of the article. The simple hand hammer is used by some as the most satisfactory test of adherence, although not susceptible to quantitative expression.

Hardness and Abrasion-Resistance

The hardness of an enamel surface is apparently regarded as an important property. British Standard Specification No. 715 includes the use of Moh's hardness scale. The powders of increasing hardness are drawn over the surface under 1 lb. per sq. in. pressure until one is found that scratches the surface. The surface must not be scratched until No. 7 (quartz) is reached. A well-known frit-making firm uses the same scale of minerals, scratching the enamel with a sharp edge, with medium, even pressure. In this case the enamel must have a hardness not less than 4 (fluorspar) or 5 (apatite). The disadvantage of using Moh's hardness scale is that the hardness of vitreous enamels does not vary greatly from one composition to another. According to Andrews[8] vitreous enamels have a hardness between 5 and 6 on this scale. Various forms of scratch hardness test using a balanced beam, with a steel gramophone needle, diamond point or glass cutter, are used in U.S.A., but the test is admittedly difficult to interpret and is regarded by the Bureau of Standards as erratic. It is difficult to say when a scratch starts. The value of the weight when a scratch appears is taken, a binocular microscope being used to ascertain when the scratch begins. In one case, one opacifier was said to reduce scratch hardness by one-half. Scratch-hardness is regarded as indicating resistance to sharp edges or abrasives.

Tests for abrasion-resistance have also been used, the apparatus taking several forms. In some cases the abrasive, *e.g.*, fine sand, is rubbed on the surface with a given pressure, while in others the samples are revolved in the abrasive, or the abrasive is projected on to the surface. The first method bears more relation to service conditions. As with acid-resistance tests, which are discussed later, the results can be interpreted in two ways, by appearance or by loss in weight. The appearance of a smooth enamel surface is spoiled as soon as the thin gloss layer is removed, although the weight of enamel removed may be extremely small. Continued abrasion does not change the appearance much, but will reduce the thickness of the enamel layer, causing an appreciable loss in weight. It is necessary to distinguish between these two cases, since once the surface layer has been removed, the rate of wear may be different. Weight loss tests are only suitable for laboratory test-pieces, but the loss of gloss can be measured on any enamelled surface. Care must be taken in laboratory tests that the application and firing of the enamel are carried out under conditions corresponding as closely as possible with works practice.

One abrasion test consists of a leather-lined shoe fed with sand and moved to and fro by means of a connecting rod on the surface to be tested. The wear is measured by loss in weight. The Bureau of Standards test, details of which have not yet been published, consist in placing in a brass tube section, on the 4-in. square test plate, a number of $\frac{5}{32}$ in. stainless-steel ball bearings with a weighed amount of water and ground felspar. The section is closed by rubber gaskets and six are mounted in a mechanical shaker. The initial and final specular reflections are taken and the ratio gives the extent of the wear which spoils the reflecting surface. Thus if the initial specular reflectance is 6 per cent., and after the test 3 per cent., the abrasion index is 50 per cent. Indices obtained range from 15 to 80 per cent., in an order corresponding roughly with experience.

The use of the words "hard" and "soft" in connection with abrasion resistance is liable to give rise to misunderstanding among enamellers, since by a "hard" enamel is often meant a refractory type of enamel, requiring a high firing temperature, while a "soft" enamel is one fired at a comparatively low temperature. It sometimes happens that one enamel is "softer," *i.e.*, more fusible, than another, and yet may be much more resistant to abrasion. The terms "hard" and "soft" have also been used in referring to the solubility of enamels.

CHEMICAL TESTS

Acid Resistance

The subject in this section on which most has been written is acid-resistance. The term "acid-resisting" has a very indefinite meaning

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in this country at present and is very liable to misinterpretation by those outside the industry. One large firm visited uses all "acid-resisting" enamel, since they have found that it gives better service in use. They do not advertise the fact, however, since they believe that this might lead users to think that the enamel would resist any acid. In contrast to this, the enameller at another firm was in favour of a special distinguishing mark for acid-resisting enamels. If a standard acid-resistance test was recognised by manufacturers, distributors and users of vitreous enamelled articles, this suggestion might be practicable, but it would hardly be possible to do it at present.

No single test for acid-resistance can really cover the wide range of conditions under which enamelled surfaces are used. Enamels must be suitably classified and a test devised for each class. The test must be carried out on enamelled objects or test-pieces, as experiments on the frit itself take no account of the effect of mill additions, or firing conditions.

In the United States, the Porcelain Enamel Institute[8] has issued a test for acid-resistance of enamels, which attempts to provide test conditions similar to those which may be expected in service. Enamels to be used at ordinary temperatures are tested at ordinary temperature for 15 minutes with 10 per cent. citric acid (corresponding to lemon juice), while enamels for cooking utensils are tested for 30 minutes with a boiling solution containing 1.5 per cent. citric acid and 1.5 per cent. malic acid (corresponding to the juice of the more acidic fruits and berries). A standard test-piece is covered with the enamel and the part subjected to the action of the acid is compared with the untreated part. In order to avoid weakening of the acid solution with use, not more than a specified area of enamel surface is tested in a litre of acid solution.

For the commercial test, the surface is examined by methods that compare the treated and untreated parts of the surface with regard to specular reflection and the ease with which a pencil mark can be rubbed from the surface by wet and dry cloths. In the research test, this is supplemented by a measurement of the specular reflectance before and after treatment with the acid. The latter value, expressed as a percentage of the former, is used as a numerical expression of acid-resistance to supplement the commercial classification.

The test described above expresses the effect of the acid on the surface of the enamel layer. Gautsch,[10] in a review of acid-resistance testing methods, suggested that, while an appearance test is quite fair for enamelled articles which are only occasionally exposed to acids, in kitchen-ware the amount of attack is important, since the enamel is exposed constantly to acid solutions. The amount of attack can be determined in several ways. The loss of weight of an enamelled object after attack by acid can be found, but this can only be done accurately for small pieces.

Karmaus,[11] in his book "Testing Methods for Enamelled Objects," describes the boiling of acid solution for half an hour in enamelled vessels, followed by evaporation of the solution in a beaker and finally to dryness in a weighed platinum or quartz dish. The weight of residue is determined and the dissolved portion expressed as milligrams per square centimetre of surface covered by the acid. Three classes of enamel are distinguished, (*a*) enamel resistant to cooking acids, for which 10 per cent. acetic acid is used; (*b*) acid-resisting enamel, for which 10 per cent. HCl is used; and (*c*) highly acid-resisting enamel, used on apparatus for the chemical industry, which should be tested under the conditions in which it is to be used. An objection to the above testing method is that it is essentially a laboratory test, involving very accurate weighing.

Reference should also be made to the British Standard Specification No. 715 test for enamel used on gas-fired appliances. In this test acetic acid of a specified strength is applied to the enamelled surface and allowed to remain in contact with it for 15 minutes. The effect of the solution is judged by the loss of strength of the acid, as measured by its increase of *p*H value. The area of surface to be tested is specified as a circle ½ in. in diameter, but no mention is made of the quantity of acid to be used. Although the amount of acid used might not make much difference when testing an enamel that is practically unaffected by this strength of acid, in the case of an enamel only passing the test by a small margin, the amount of acid used might decide whether it passes or not. The usefulness of the test in its present form depends on the rate of change of *p*H with time, whether this is gradual and uniform, or rapid at first and then falling off. This might depend on the chemical composition of the enamel.

After consideration of all these testing methods, the comparison of the appearance and texture of the enamel surface before and after acid attack appears to offer the most promise as a criterion of acid-resistance. One U.S. laboratory classes enamels after the test as (*a*) No effect under acid; (*b*) Iridescent stain, and (*c*) Bare patch. The use of different acids for testing enamels intended for different purposes also has much to commend it. In the case of some acid-resisting enamels which are fired at a somewhat higher temperature, underfiring will give a surface of which the acid-resistance is different from that of the correctly fired enamel. When testing such enamels, care must be taken to ensure that the firing conditions are correct. Less trouble is experienced with some modern acid-resisting enamels in this respect, as their firing temperature is very little higher than that of a normal type of enamel.

Alkaline Resistance

For some purposes, *e.g.*, for baths, enamel must be resistant to alkaline solutions. Most bath enamels are rather "soft" (fuse at a low temperature), but can be made to withstand the action of a very weak soap solution. For an enamel to withstand the use of bath salts, much greater resistance to alkali is necessary, especially for coloured enamels as attack by alkali may alter the colour. The attainment of very high alkali resistance often involves some sacrifice of acid-resistance and a compromise may therefore be necessary.

To devise a suitable test for alkali-resistance, an investigation of the properties of present-day enamels would be necessary, in order to ensure that a reasonable standard is set. Karmaus describes the use of boiling 10 per cent. sodium carbonate or sodium hydroxide solution, under conditions similar to those used for the acid-resistance test previously described. Stuckert[12] used 10 per cent. sodium carbonate solution, which was boiled for an hour in small enamelled test-vessels. An investigation of the alkali-resistance of the enamels at present in use would be of considerable value in view of the strongly alkaline nature of many proprietary compounds which may be used for cleaning vitreous enamelled surfaces.

Conclusion

Of the various tests described, those for opacity and adherence are regarded as of most importance. Opacity, or reflectance, can now be very accurately measured, but adherence, whether estimated by means of thermal expansion or by mechanical tests, cannot yet be regarded as subject to satisfactory estimation. The apparatus described does not appear to be used in this country to any great extent, and it is suggested that at least one central laboratory, available to frit-makers and users alike, could with advantage be equipped, where these and other material and process tests could be made.

The following summarises the tests found to be in use in U.S.A. and the apparatus employed.

Test	*Apparatus*
(1) Reflectance (Opacity).	Hunter Reflectometer.
(2) Colour.	Spectrophotometer.
(3) Thickness.	Thickness gauge.
(4) Thermal expansion.	Interferometer.
(5) Micro examination.	Metallurgical microscope.
(6) Adherence.	Impact test.
(7) Abrasion resistance.	Various.
(8) Acid resistance.	Standard test P.E.I.

Warm thanks are due to a number of U.S. firms, frit-makers and enamellers for their assistance in discussing their testing practice.

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Australian Foundrymen Form Technical Institute

A large and representative gathering of those immediately interested in foundry practice met recently at the Melbourne Technical College, when it was decided to form the Australian Institute of Foundrymen. Considerable spade work had previously been carried out, and after the objects of the Institute had been clearly put to the meeting, it was agreed to form a provisional committee to examine the submitted draft constitution in detail and that this should be submitted to a general meeting to be called early in the New Year.

The committee elected was as follows:—*President*, Mr. W. Main; *Secretary*, Mr. B. Russell; *Committee*, Messrs. W. Allen, R. A. Cheers, A. A. Robertson, C. R. Day, G. J. Benson, W. Hewitt, Harcourt, L. G. Cuming, S. Thompson, and F. Moss. This committee is particularly well balanced, in that of those chosen, five are associated with iron and steel founding, three with non-ferrous and two with foundry work generally.

It is the definite objects of the Institute to be purely educational; commercial matters and the relations between employer and employee will not be within its scope. It will strive to provide a means of advancing knowledge of foundry practice in its widest sense by the discussion of overseas developments, technical Papers, and the cordial interchange of views and experience in actual practice.

Membership may be classified into three sections, thus admitting the student and journeyman, as well as the executive, to full participation in all the advantages. It is proposed to initiate, conduct and supervise research into the science and technology of the art of metal and alloy production, casting and working. In addition to this, systems of education will be organised, conducted or advised upon for forwarding the education of all or any grades of operatives in metal casting. Broadly, the Institute will function along lines largely similar to kindred organisations which have achieved so much commendable work in Great Britain, and as this is, perhaps, the first of its kind to be formed in Australia, it is hoped to establish active affiliated branches in other States and important industrial centres.

The objects of the Australian Institute of Foundrymen are, indeed, worthy of the encouragement and support of the foundry industry, and we congratulate those who have already carried out the difficult preliminary work and wish the new organisation every success.

HOLWELL IRON

in Machine-cast Pigs

For light castings

SPECIFICATION:

Weight	-	-	60-70 lbs.
Length	-	-	19½ inches
Width	-	-	8½ inches
Thickness	-	-	3¾ inches

The chemical analysis and well-known physical properties of Holwell Iron remain unaltered.

CLEANER MELTING
SAVING IN FUEL

The Stanton Company have many years' experience of metallurgical problems. This experience is at your disposal on any problem in connection with the Foundry.

The Stanton Ironworks Company Limited, Near Nottingham

The Largest Producers of Foundry Pig Iron (for Sale) in Great Britain

The Week's News in Brief

Trade Talk

BRITISH ACHESON ELECTRODES, LIMITED, have changed their address to Grange Mill Lane, Wincobank, Sheffield.

IN ORDER to protect their Devonshire Works, Chesterfield, the Staveley Coal & Iron Company, Limited, have decided to train the whole of the employees in fire-fighting.

A NEW CUSTOMS DUTY of 37½ per cent. (preferential duty 25 per cent.) on certain imports of iron and steel goods, imposed by the Eire Government, came into operation on November 1.

THE BRITISH COAL UTILISATION RESEARCH ASSOCIATION is to establish an experimental station in London. Premises at West Brompton are now in course of being converted and equipped.

A SLIGHT OUTBREAK of fire occurred at the Torwood Foundry, Larbert, of Jones & Campbell, Limited, on October 27. It was caused by the heat from a stove in the core-shop igniting the wooden sides of the building.

THE 90TH ANNUAL ANNIVERSARY DINNER of the Royal Metal Trades Pension and Benevolent Society is to be held on December 6 at the Dorchester Hotel, London, under the chairmanship of Colonel J. H. M. Greenly, C.B.E.

A NEW WELDING ELECTRODE has recently been developed by the Lincoln Electric Company, Limited, of Welwyn Garden City, for depositing a soft machinable alloy on cast iron. This electrode has been designated "Softweld."

THE BRITISH ALUMINIUM COMPANY, LIMITED, in association with Swiss and other interests, is to erect a new plant at Newport, Mon. This work will be undertaken by a new private company just registered with the title of the South Wales Aluminium Company, Limited The capital is £500,000 in £1 shares.

MACKENZIE & MONCUR, LIMITED, Edinburgh, have secured the contract to supply lamp standards for a new road in Aberdeen leading from Holburn Street to the new bridge over the Dee. Eighteen of the standards will be double-armed, and will be erected between the twin carriageways, while 46 others will be single-armed.

THE COMMERCIAL WORKS at Roath Basin, Cardiff, recently vacated by Robert R. Paton, Limited, has been taken over by Mr. H. D. Evans, who was formerly associated with the Titan Foundry, Cardiff. The offices of the business, which will deal largely with iron and brass founding, will be at 73, James Street, Cardiff Docks.

THE OFFICIAL INAUGURATION of the Institute of Petroleum will take the form of a conversazione and lecture, to be held on Tuesday, November 8, at the house of the Royal Geographical Society, Kensington Grove, London. Guests will be received by Col. and Mrs. S. J. M. Auld and Capt. H. F. C. Crookshank, M.P. (H.M. Secretary for Mines) from 8.0 p.m.

THE INDUSTRIES COMMITTEE of the Jarrow Town Council has had under consideration the industrial position and ways and means of providing remunerative employment for the town's workpeople. The Committee states that even if the proposed new steelworks were in operation there would still be about 2,000 people unemployed. It has been agreed therefore to proceed with the Bill prepared for the 1936-7 Session of Parliament which has lain in abeyance. The Bill seeks to enlarge the Council's powers with respect to the acquisition, development and disposal of lands and for the economic development and social improvement of the Borough. It has also been decided that the new Jarrow Steel Company be asked to indicate what industries ought to be projected auxiliary to the new steelworks with a view to action being taken by the Council to assist.

Contracts Open

Leicester, November 12.—Sewerage ironwork, for the year ending December 31, 1939, for the Town Council. The City Surveyor, Town Hall, Leicester.

Glastonbury, November 15.—Iron castings, for the year commencing April 1, 1939, for the Borough Council. Mr. R. O. Winfield, borough surveyor, Borough Surveyor's Office, Glastonbury.

Personal

MR. R. P. W. ADEANE has been elected a director of Ransomes & Rapier, Limited, engineers and iron-founders, of Ipswich.

MR. J. S. HALES has been appointed to take charge of the domestic appliances department of the British Coal Utilisation Research Association.

MR. ARTHUR MATTHEWS, a director and general works manager at Sheffield of Thos. Firth & John Brown, Limited, has been appointed assistant managing director of the company.

MR. J. H. HURST, M.I.Mech.E., has resigned his appointment with Steel, Peech & Tozer, of Sheffield, to take over the position of general manager of the Wycliffe Foundry Company, Limited, Lutterworth, near Rugby. He commenced his new duties on November 1.

MR. C. J. WALSH, managing director of the Appleby-Frodingham Steel Company, Limited, a subsidiary of the United Steel Companies, Limited, has been appointed a director of the United Steel Companies, Limited, and to the office of assistant managing director.

SIR HAROLD YARROW has been presented by the Yugoslav Government with the Order of St. Sava (First Class), and two of his co-directors, Mr. J. Paterson and Mr. W. Marriner, with the Order of St. Sava (Third Class), in appreciation of their services in carrying out engineering work on two destroyers for the Yugoslav Navy.

TO MARK his resignation from the position of managing director of the company and his retirement from any active part in the conduct of the business, Mr. A. E. Hurst entertained about a hundred employees of Samuel Russell & Company, Limited, Northcote Street Foundry, Walsall, to supper on Saturday, and his guests expressed their feelings towards him by presenting him with two armchairs and also made a gift of a brown calf-skin handbag to Mrs. Hurst. Mr. George Nicklen, one of the oldest employees, paid a tribute to Mr. Hurst and said besides extending the business in many directions he had brought the works completely up to date according to the standards of modern foundry practice. Miss E. M. Venables made the presentation to Mrs. Hurst.

Obituary

MR. F. C. IHLEE, vice-chairman of Baker Perkins, Limited, engineers and founders, has died at his home at Peterborough, aged 70.

MR. E. LUNN, who founded the firm of E. Lunn & Company, Limited, bottle-mould makers and engineers, of Mount Street, Glasgow, has died in a Glasgow nursing home. He started the company in 1912, and retired only a few months ago.

MR. THOMAS L. PRICE, veteran director of Blackstone & Company, Limited, of Stamford (Lincs), died suddenly on Tuesday at his home in Stamford. Mr. Price was in his 85th year, and was still actively engaged in business. He had the distinction of having attended every Royal Show since 1871, and of having missed only a single day at any one of them. Born and educated in Shrewsbury, he joined the Blackstone firm, then known as Jeffery & Blackstone, in 1884, as sales representative for the British Isles, when the firm's chief products were portable steam engines and hay-making machinery. In 1924 he became home sales manager, and in 1935 was elected to the board.

New Companies

(From the Register compiled by Jordan & Sons, Limited, Company Registration Agents, 116 to 118, Chancery Lane, London, W.C.2.)

J. Rastall & Son, Limited, Works, 365, Chester Road, Manchester.—Capital, £1,000. Iron and brass founders, mechanical engineers, etc. Directors: J. F. and E. A. Rastall.

South Wales Aluminium Company, Limited, 1, Oxford Court, Cannon Street, London, E.C.4.—Capital, £500,000. Directors: Lt.-Col. Sir Rhys Williams, Bt., K.C., A. Bloch, E. Kaufmann, W. M. Morrison and E. G. MacDowell.

Company Reports

Tweedales & Smalley (1920), Limited.—Interim dividend of 2½ per cent.

Crabtree Electrical Industries, Limited.—Final dividend of 5 per cent. and a cash bonus of 7½ per cent., making 17½ per cent. for the year.

Leeds Fireclay Company, Limited.—Final dividend of 5 per cent. on the preference shares, making 7 per cent., and a dividend of 5 per cent. on the ordinary shares.

Lightalloys, Limited.—Profit for the year ended June 26, £41,489; brought in, £6,079; to tax reserve, £5,000; to reserve, £8,750; final dividend of 1s. 1½d. a share, making 1s. 9d. on each 5s. share for the year; carried forward, £5,319.

Wolverhampton Die-Casting Company, Limited.—Net trading profit for the 15 months ended June 30, £24,701; depreciation of property, plant, machinery, etc., £5,595; reserve for income tax and N.D.C., £3,326; net profit, £11,092; dividend of 5 per cent. on the ordinary shares; carried forward, £1,970.

Ferranti, Limited.—Net profit for the year to June 30, after making provision for general establishment charges, bad debts, repairs and renewals, income tax and N.D.C., staff pensions premium, discount and interest, fees and depreciation, £68,263; brought in, £56,395; dividend on the 7 per cent. cumulative preference stock, £35,000; to general reserve, £15,000; dividend of 6 per cent. on the ordinary stock, £18,000; carried forward, £56,658.

Birmingham Small Arms Company, Limited.—Profit for the year ending July 31, after £207,551 for depreciation, £630,424; debenture stock interest, £62,220; fees, £7,908; brought in, £204,761; income tax and N.D.C., £100,000; premium on redemption of debentures, £719; reserve for repayment of debenture stock, £28,950; additional reserve, £196,050; ordinary dividend of 10 per cent., £204,100; carried forward, after preference dividend, £212,624.

Forthcoming Events

NOVEMBER 8.

Institute of Metals (Swansea Section):—"Copper Alloys and Their Adaptation to Modern Engineering Requirements." Paper by H. J Miller, at Y.M.C.A., Swansea, at 6.30 p.m.

Institution of Mechanical Engineers (South Wales Branch):—Paper on "Production of Special Steels in Thos. Firth & John Brown's Works," at Royal Metal Exchange, Swansea, at 6 p.m.

NOVEMBER 9.

Manchester Association of Engineers:—Second annual Manchester Association of Engineers' Lecture: "Span," by F. W. Lanchester, LL.D., F.R.S., at College of Technology, Manchester, at 7.30 p.m.

NOVEMBER 10.

Institution of Chemical Engineers (Graduates' Section):—"Use of Acid-Resisting Vitreous Enamel in Chemical Plant," Paper by W. E. Benton, at Caxton Hall, London, S.W.1, at 6.30 p.m.

NOVEMBER 11.

Chesterfield and District Engineering Society:—Joint meeting with East Midlands Branch of Institution of Mechanical Engineers: visit to Bryan Donkin & Company's works at 3 p.m.; "History of the Locomotive," Paper by Prof. C. H. Bulleid, at Chesterfield Technical College, at 7 p.m.

Institute of Metals (Sheffield Section):—"Expert Use of the Microscope," Paper by H. Wrightson, at Applied Science Department of Sheffield University, at 7.30 p.m.

NOVEMBER 14.

Institute of Metals (Scottish Section):—Works visit, Glenfield & Kennedy, Limited, Kilmarnock, at 8 p.m.

Institute of British Foundrymen

NOVEMBER 8.

Burnley Section:—"Melting Practice in the Foundry," Paper by S. E. Dawson, at Municipal College, Ormerod Road, Burnley, at 7.30 p.m.

NOVEMBER 12.

Bristol Section:—"Non-Ferrous Castings," Paper by C. A. Howe, at Merchant Venturers' Technical College, Bristol, at 7 p.m.

Scottish Branch:—"Making Large Lathe Beds," Paper by W. Y. Buchanan, at Royal Technical College, Glasgow, at 4 p.m.

West Riding of Yorkshire Branch:—Works visit to R. W. Crabtree & Sons, Limited, and the Crabtree Foundry Company, Leeds.

The Institute of Vitreous Enamellers

NOVEMBER 10.

Southern Section:—"Problems of the Users of Vitreous Enamelled Ware," symposium led by C. A. Masterman, at Charing Cross Hotel, London, at 8 p.m.

ONCE more the Season of Good Will draws nigh and though we would be loth to interrupt your thoughts of the festivities to come, we feel that in your own interests we must remind you that now is the time to order your supplies of Firebricks, Silica Bricks and Basic Bricks, etc., for your Christmas Repairs. Orders placed at once can be executed in time for Christmas, enabling you to avoid the delay and disappointment which so often accompanies last-minute demands for supplies.

Our Technical Staff is at your service for advice on any problem regarding the selection of the most suitable grade of refractories to meet your needs.

A FEW OF OUR PRODUCTS:

FIREBRICKS	SILICA BRICKS	BASIC BRICKS
GLENBOIG	LOWOOD	SAXPYRE
WHITE CARR	ALLEN	SPINELLA
HALIF AX	MELTHAM	DIAZITE
STOUR	BAWTRY	SUPERMAG

AMBERLITE INSULATING BRICKS, CEMENTS AND CONCRETES, ACID-RESISTING BRICKS AND CEMENTS, REFRACTORY CEMENTS AND SANDS OF EVERY DESCRIPTION.

GENERAL REFRACTORIES LIMITED,

GENEFAX HOUSE, SHEFFIELD, 10.

Telephone: Sheffield 31113 (6 lines). *Telegrams:* "Genefax, Sheffield."

Raw Material Markets

Reports from all districts indicate a return of confidence in the iron and steel industry, and, although business is restricted by the absence of news regarding future prices, many consumers are having to take up additional tonnages, as their stocks have become quite low. Producers experience no difficulty in meeting current requirements, despite reduced outputs, and it will be a considerable time before their stocks have been eliminated.

Pig-Iron

MIDDLESBROUGH.—Consumers who have still supplies to take up under existing contracts are now calling for deliveries more freely. Other users are placing small orders, but new contracts do not extend beyond the end of the year, as it is generally expected that next year's prices will be lower than current rates. There are definite signs of returning activity at many of the consuming plants, and it is anticipated that orders for pig-iron will show a marked expansion in the new year. Export business is still disappointing, while deliveries to Scotland have a long way to go before attaining their former level.

While makers of foundry iron may soon have to increase their production, the current output of hematite is more than sufficient to meet the needs of the consumers. There has certainly been some expansion in demand, but in most cases consumers are heavily contracted ahead. Conditions in the export section show little improvement from week to week. Business with Italy is still held up by the difficulty of arranging credits; Italy was formerly the largest foreign user of East Coast hematite, and the loss of trade in this direction is badly felt.

LANCASHIRE.—Contract deliveries of foundry iron continue to increase, and there is a more hopeful feeling in this area. Heavy electrical engineers and machine-tool makers are well employed, while speciality engineers and some jobbing foundries are now better placed for orders. Textile machinists and light-castings makers are still quiet. For delivery to users in the Lancashire area, offers of Staffordshire and Derbyshire brands of No. 3 foundry iron are on the basis of 114s., with Northamptonshire at 112s. 6d. and Derbyshire forge iron at from 111s. to 113s., according to the class of user. Although there has been some expansion in the call for hematite, business remains on the quiet side. West Coast hematite is quoted at 141s. and East Coast at 140s. 6d., both for delivery equal to Manchester.

MIDLANDS.—Ironfounders' stocks of high-phosphorus iron are slowly being reduced, as consumers themselves have now little material in hand. New orders are only for small parcels for early delivery, but the aggregate tonnage is quite substantial. Makers' stocks, however, are heavy and can readily meet the demand. A similar position exists with regard to forge pig-iron and delivery specifications are for small tonnages. Low-phosphorus pig-iron continues to be well taken up. No control being in operation on this iron, prices are largely a matter of negotiation between makers and users, and the former are generally willing to consider concessions where large tonnages are involved. A much brighter outlook is now apparent in hematite, but contract schedules have fallen a long way behind.

SCOTLAND.—Doubt still exists in local iron circles as to whether a reduction will be made in prices when they come up for consideration. The concensus of opinion is that lower rates will be brought into operation, but some consumers are not placing too much reliance on this. Current quotations are 120s. 6d. for No. 1 foundry iron and 118s. for No. 3, f.o.t. furnaces. There is little change to report in conditions at local steelworks. Prices of steel-making irons are unaltered at 133s. for hematite mixed numbers, 107s. 6d. for Scottish basic, and 100s. for English and Indian basic, all less 5s. rebate, delivered f.o.t. steelworks.

Coke

Active conditions prevail in the foundry coke market and business with both home and overseas consumers has been quite brisk. Prices will be maintained at their present levels at least up to the end of the year. For delivery to Birmingham and Black Country stations, best Durham coke is quoted at 50s. 6d., with Welsh at a minimum of that figure.

Steel

Rather brighter conditions have developed in the steel market and the change is noticeable in practically all departments of the industry, says the official report of the London Iron and Steel Exchange. This is largely the result of the reduction in the stocks of Continental steel which have been weighing on the market for several months and also to a broadening in the requirements of some classes of consumers. Transactions are still limited for the most part to delivery before the end of the current year, but there is a definite expansion in the number and the tonnage asked for. In the semi-finished steel section, there has also been a notable improvement in the requirements of the consuming trades, and most of the works are better employed than for some time past. There has been a considerable amount of activity in the special steel departments arising from the demand in connection with the re-armament programme. In the finished steel section of the market, the majority of the works are operating at about 60 per cent. of capacity, and most of the mills have experienced a satisfactory influx of new business recently. Little has been contracted for beyond the end of the year, and it is anticipated that when the prices for 1939 delivery are settled business will considerably expand. Although the export demand is still restricted, a number of markets has shown more interest and prospects appear brighter than for some time.

Scrap

Business in iron scrap continues to increase. Owing to the lower stocks of pig-iron, many foundries are making use of machinery cast-iron scrap and some good tonnages are changing hands. Most orders are restricted to fairly small parcels for early delivery, but the aggregate turnover is satisfactory compared with a few weeks ago. Steel scrap prices have yet to be fixed.

Metals

Copper.—Consumers have continued to take up deliveries quite freely, but little new business has been placed. Any transactions that are made are generally for early deliveries. In the United States, trade is on quite a good scale; domestic sales over the first half of October totalled about 55,000 short tons. Industrial conditions in America continue to show improvement, and the outlook is satisfactory. It is reported that the utility companies intend shortly to place orders worth many millions of dollars. This is welcome news and has been brought about by the elimination of a large part of the discord which has existed between the companies and Washington. These orders are expected to involve a very substantial quantity of copper.

Metal Exchange quotations were as follow :—

Cash.—Thursday, £46 15s. to £46 16s. 3d.; Friday, £46 11s. 3d. to £46 12s. 6d.; Monday, £45 12s. 6d. to £45 15s.; Tuesday, £46 to £46 2s. 6d.; Wednesday, £45 15s. to £45 16s. 3d.

Three Months.—Thursday, £46 18s. 9d. to £47; Friday, £46 15s. to £46 16s. 3d.; Monday, £45 17s. 6d. to £45 18s. 9d.; Tuesday, £46 5s. to £46 6s. 3d.; Wednesday, £46 to £46 1s. 3d.

Tin.—Trade demand for this metal is still rather dull in this country, but the tone of the market remains firm. Rather more activity is reported to be developing in America, but the tinplate mills are still very badly situated for work. Shipments of tin from the Yunnan tinfields of China have continued to be made quite satisfactorily on the whole, despite the enormous difficulties under which the nation is at present labouring, but the further penetration into China by the Japanese forces is raising doubts as to whether the tin will in future be shipped so easily.

Mr. W. H. Gartsen reports that the total visible supply of tin at the end of October amounted to 30,359 tons, against 30,869 tons on September 30. These figures include the carry-over in Straits Settlements and at the Arnhem (Holland) smelter.

Official quotations were as follow :—

Cash.—Thursday, £211 10s. to £211 15s.; Friday, £212 17s. 6d. to £213; Monday, £210 15s. to £211; Tuesday, £212 10s. to £212 15s.; Wednesday, £211 15s. to £212 17s. 6d.

Three Months.—Thursday, £212 10s. to £212 15s.; Friday, £213 10s. to £213 15s.; Monday, £211 15s. to £212; Tuesday, £213 5s. to £213 10s.; Wednesday, £212 15s. to £212 17s. 6d.

Spelter.—Business has been rather dull, but the tone of the market has been maintained. A formal objection has been made on behalf of various zinc interests to the Import Duties Advisory Committee against the proposal to alter the existing import duties on the metal. It is understood that the committee of zinc consumers is still formulating its views on the proposed modification of the zinc duties, for presentation to the I.D.A.C. The report will not be completed for some time.

Daily market prices :—

Ordinary.—Thursday, £15 7s. 6d.; Friday, £15 5s.; Monday, £14 17s. 6d.; Tuesday, £14 16s. 3d.; Wednesday, £14 11s. 3d.

Lead.—The lead requirements of the armament makers continue to be heavy, and demand is well maintained from this source. Some other industries, however, are rather less active. An announcement is eagerly awaited from the Lead Producers' Association. The consensus of opinion is that if restriction of production is imposed, it will be small: a figure around 5 per cent. is suggested.

Day-to-day quotations :—

Soft Foreign (Prompt).—Thursday, £16 10s.; Friday, £16 8s. 9d.; Monday, £16 2s. 6d.; Tuesday, £16 1s. 3d.; Wednesday, £16.

Scrap.—A moderately good trade has been experienced recently. Most consumers are taking up small supplies, but there is now an absence of speculative buying, which had been to the fore during the past few weeks. Most prices are slightly higher on the week.

Approximate selling prices for old metal :—New aluminium cuttings, £70; rolled, £54; cast, £30; foil, £80. Copper, £40 to £45; braziery, £35 to £36. Brass (clean), £22 to £25. Zinc, £11 10s. Lead, £14 10s. Gunmetal, £41 to £42.

Patent Specifications Accepted

The following list of Patent Specifications accepted has been taken from the "Official Journal (Patents)." Printed copies of the full Specifications are obtainable from the Patent Office, 25, Southampton Buildings, London, W.C.2, price 1s. each. The numbers given are those under which the Specifications will be printed and abridged, and all subsequent proceedings will be taken.

490,916. WILLIAMS, W. P. (American Rolling Mill Company). Butt-welding devices for metal strip.

491,023. I. G. FARBENINDUSTRIE AKT.-GES. Method of, and means for, preventing corrosion of metal parts in cooling or heating systems.

491,174. UNITED STEEL COMPANIES, LIMITED, and BACON, N. H. Metal casting.

491,225. WAGNER, K. F. Apparatus for the casting of metals in chills.

491,311. WOODWARD, W. E., ALLEN & SONS (TIPTON), LIMITED, W. G., and OSBORN & COMPANY, LIMITED, S. Manufacture of steel.

491,341. METAL CARBIDES CORPORATION. Casting of metal.

491,375. MCMINN, W. W. Manufacture of hollow metal tubes or shafts.

491,415. BOSCH AKT.-GES., R. Improving the compressibility of metal powders.

491,423. BARTSCHERER, F. Method of, and apparatus for producing hollow bodies in centrifugal casting moulds.

491,528. HUNTZICKER, P. Production of alloys.

491,572. CLARK, G. M. (Steirische Guss-stahlwerke Akt.-Ges.). Production of high-speed tool steels.

491,620. SMITH, H. C. Metal heating furnaces.

491,639. BANDEISENWALZWERKE AKT.-GES. Cold-rolling mill for rolling endless bands.

491,640. LATTRE, P. DE. Regenerating pickling-baths.

491,673. FIRTH-STERLING STEEL COMPANY. Manganese steel.

491,722. RHEINMETALL-BORSIG AKT.-GES. Manufacture of sintered hard articles containing metallic carbides.

491,814. MORTON, W. A., and SPENCER, H. F. Furnace for heating steel ingots.